SCIENTIFIC AMERICAN SUPPLEMENT No. 491

Scientific American Supplement, Vol. XIX., No. 491.
Scientific American, established 1845.

NEW YORK, MAY 30, 1885.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

CAPAZZA'S LENTICULAR BALLOON.

WITH the aid of the accompanying diagrams it is our purpose to describe a method of aerial navigation devised by Mr. Capazza, a young engineer who, in conjunction with Mr. Livrelli, has attached his name to the campylograph. Although experienced aeronauts, who know the difficulties of the problem, may doubt the feasibility of the plan, we think at least that they cannot refuse to admit its boldness and originality. Drawn this way and that by the partisans of "the heavier" and "the lighter than the air," Mr. Capazza said to himself that the best thing to do was to agree with both, and to apply the ideas of both schools at one and the same time.

Occupied from the start with the stability of his apparatus, and at the same time with a means of steering it easily, M. Capazza has adopted the lenticular form, with an entire, sharp edge. This form is sufficiently indicated in Fig. 1, which represents the balloon cut vertically through its axis. A A are two much flattened cones connected at their bases by means of an air-tight, bellows-like coupling. This latter is covered by a bordering, *b b*, of a material sufficiently flexible to allow it to increase or diminish in diameter.

As the balloon has to be absolutely tight, the surfaces of the two cones are formed of very thin sheets of metal supported by a light framework whose main pieces bear against the corners of the bellows-like circumference and the central parts forming a point,

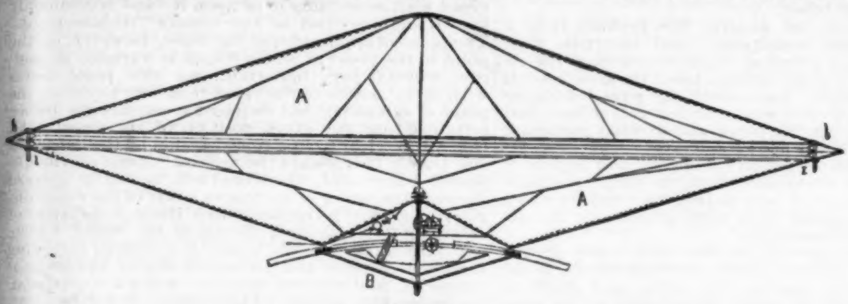


Figure 1

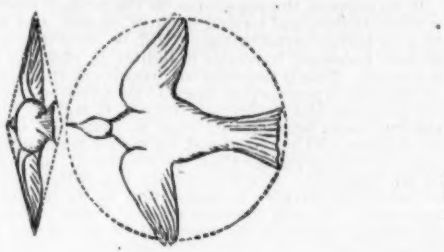
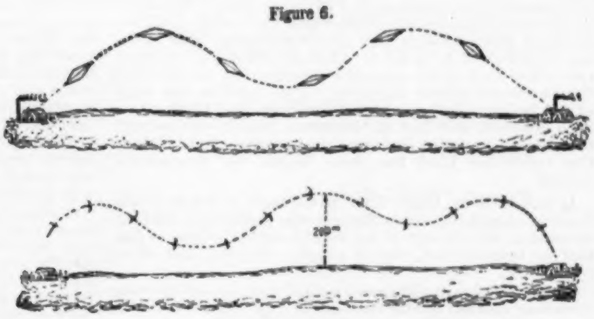


Figure 6.



Figures 7 et 8.

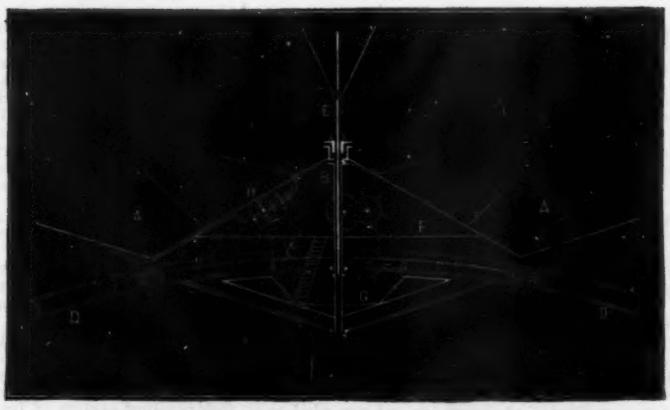


Figure 2.

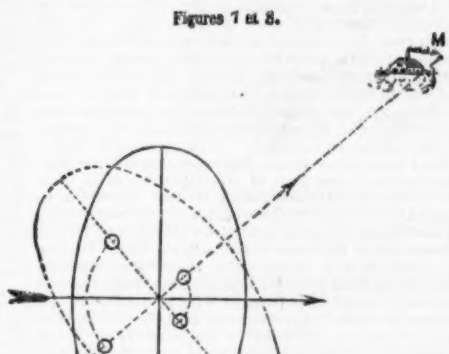


Figure 9.

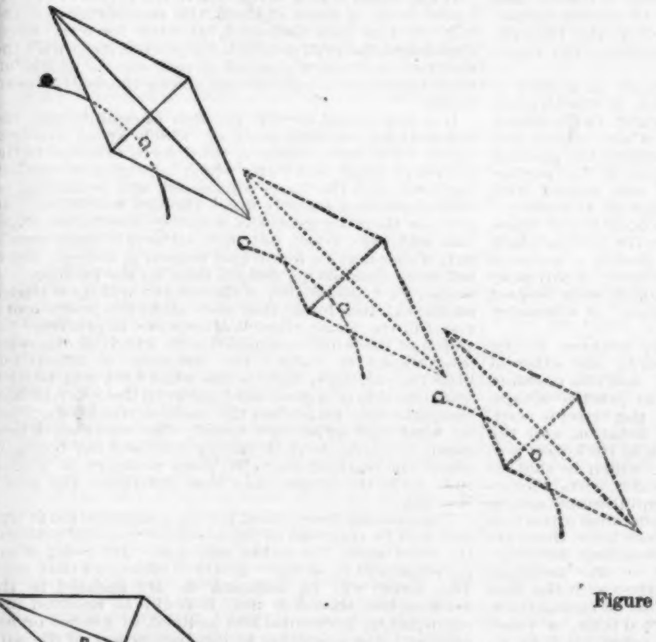


Figure 4.

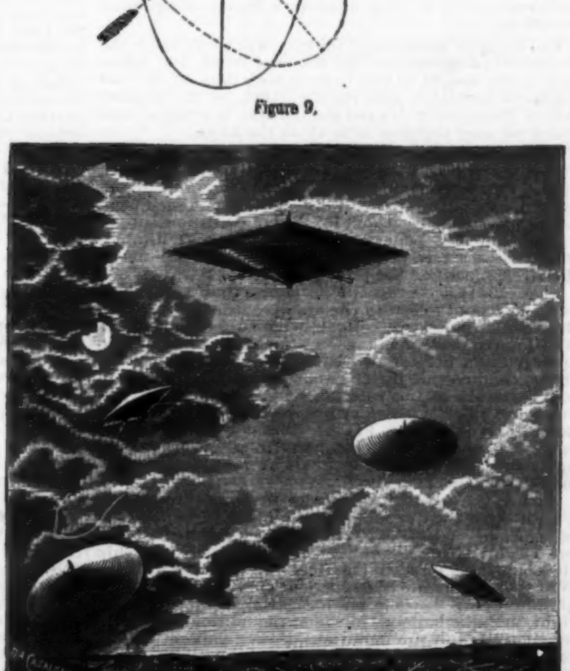


Figure 10.

Figure 5.

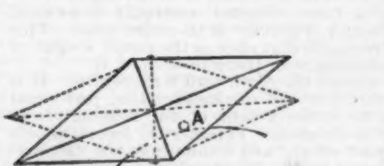


Figure 3.

THE CAPAZZA LENTICULAR BALLOON.

The inner surface is covered with a substance that is a non conductor of heat, in order to prevent abrupt changes of temperature. It will be at once seen that the balloon, filled with hydrogen, will have to be of large bulk, and of large diameter at the center, in order to possess sufficient ascensional power.

The apex of the lower cone is re-entrant, and forms a maneuvering chamber (Fig. 2), which is traversed, through the intermedium of a stuffing box, by a central rod, E, that forms the apex of the upper cone. Beneath the maneuvering space there is a car, which is attached by its center to the sheath, B, that envelops the central rod and is strongly fixed to the lower cone. A floor, F, serves for carrying the meter or electric machine, which acts, through pinions, upon a rack connected with the rod, E. The gas is introduced and removed through a double cock, H.

Between the floor, F, and the car, G, which are firmly united through the intermedium of the central sheath, and connected by a ladder, is interposed a curved rail, D D, capable of revolving completely around the sheath, B. Over this rail roll weights, *c c*, which are connected with each other by a rod, G, provided with a rack that gears with a pinion. This arched rail is strengthened by two arms that bear against the shoulder, *e*.

We may now, by means of Figs. 1 and 2, which show us the form and arrangement of the apparatus, understand its peculiar features and mode of operation

If we suppose the apparatus on the ground, provided with its ballast and having its crew aboard, and being then in perfect equilibrium, it will be seen that it will be only necessary to render it lighter in order to have it ascend. Now if the internal pressure at the moment of starting is perceptibly equal to the external barometric pressure, and if, through the rod, E, and the motor, the two cones be separated ever so little, the bulk of the balloon will increase, and, its weight remaining the same, it will be lighter than the weight of the volume of air displaced. It will therefore rise with a velocity so much the greater in proportion as its volume has increased. If such increase be one cubic meter, the ascensional power at the start will be about one kilogramme; and, in measure as the balloon rises, the external pressure diminishing, it will be so much the easier to favor its expansion and increase its speed until the moment when, finding the speed sufficient, and desiring to reduce it in order to change direction, we maneuver the rack in an opposite direction so as to bring the two cones closer together. This reduces the bulk of the balloon and renders it heavier, and thus causes it to descend, and find in the strata that it successively traverses a greater barometric pressure, that aids in the reduction that has been begun by mechanical means.

It will be seen, then, that advantage is taken of the faculty of making the balloon to rise or descend without causing it to lose any of its weight, either of gas or ballast or burned fuel, and in simply utilizing the effect of gravity.

Nevertheless, it will be seen that the ascending or descending motion of the balloon will be quite slow if it be exerted vertically, on account of the side surface of the apparatus forming a sort of parachute. It will also be seen that the vertical motion is not the true one sought, unless it be a question of simply going to find a current of air that has the desired direction The motion of the balloon, which is so difficult when it occurs parallel with the great circle of its equator, becomes easy when the sharp edge of the balloon is parallel with the plane of motion. Now, in order that a motion shall take place in an oblique upward direction, no matter toward what part of the horizon, it is only necessary to set the rail according to the direction to be taken, and then to move the weights, *c c*, in such a way as to displace their common center of gravity, and throw it a little outside of the axis of the central rod. In this way, the balloon will incline the necessary amount (shown by the dotted lines in Fig. 3), and then, instead of rising in a vertical direction, in which, owing to its wide surface, it would experience a notable resistance, it will move forward edgewise in the direction of the least resistance—for example, upward toward the right as shown in Fig. 4. Fig. 5 shows a travel of opposite direction.

The oblique ascensional velocity will be so much the greater in proportion as, on the one hand, the difference in the weight of the balloon and that of the air displaced is greater, and, on the other, as the inclination of the equator toward the horizon is greater, and which we may suppose to be 45° at the most.

We can now perceive that the form adopted by the inventor is rational, seeing the object that he had in view. Fig. 6, from the two perimeters that are circumscribed in plan and elevation, shows that such form naturally simulates the bird itself with outspread wings, and that penetration edgewise is facilitated, while eddies astern are avoided, and the reactions of the air displaced at the prow are in great part utilized.

Figs. 7 and 8 show the sinuous course that one of these balloons would follow in the air were it maneuvered in the manner indicated. Fig. 9, which represents an inclined apparatus in plan, shows the change in direction operated in a horizontal plane, and consequently the change in direction toward another point of the horizon, by means of the rotation of the rail, which performs the office of a rudder in a vertical as well as in a horizontal direction. Fig. 10 shows a flotilla of Capazza balloons sailing in company in all positions and in all directions, and moving about in the air pretty much as fish do in water.

Such is the apparatus that the inventor proposes as a solution of the difficult problem of permanent aerial navigation. Will those savants who have seen the caprices and surprises of Æolus find in this air ship the conditions of stability that the inventor claims? Will they admit the possibility of constructing, before aluminum has become an industrial metal, a strong, tight, metallic balloon, in which the motions of the different parts and the variations of the temperature will cause no troublesome disturbance of the conditions of tightness and equilibrium? Will they acknowledge that this new armor-clad of the air will be able to sport with the fury of the tempest, and sail forward, either directly or by tacking, against winds of from 8 to 9 meters per second? Mr. Capazza will doubtless be glad to have his project criticised.—*Chronique Industrielle.*

STABILITY AND SPEED OF YACHTS.—A PROBLEM OF MECHANICS IN THEORY AND PRACTICE.

THE various requirements of use have given rise in water craft to the trial of nearly every form of floating body, each possessing qualifications designed to serve a certain purpose, and generally gained at the expense of a corresponding loss in points equally important for another.

In view of the great variety of shape that still prevails, it is at once apparent that in order to arrive at definite conclusions regarding a particular feature, such as a boat's stability regarded as a floating body, or its speed as a moving one, the discussion must necessarily be confined to a comparatively small class of the same general type. In the class selected for our consideration, we observe that certain incentives in the construction of this small class alone have led to great variety, both in rig and model, determined not only by the results desired, but in a great measure by the individual ideas of the mechanic or builder as to what particular arrangement of parts would seem most conducive to the desired end, whether speed, stability, sea-going qualities, or room; and even while having the same results in view, we still witness an apparently endless struggle for supremacy between two varieties of the same class. They are diametrically opposed in principle, and will be at once recognized as the broad and shallow boat on the one hand and the narrow and deep craft on the other.

Let us endeavor to analyze this problem from a purely theoretical standpoint, and ascertain what theory teaches of practical value concerning the respective merits of these two species of the same general class of sailing craft. Let us see if the pure mechanics of the problem point to any practical advantage that one may possess over the other, and to what particular end that advantage is most conducive.

To make the investigation intelligent and logical it will be necessary to consider, first, the simple mechanical principles involved, and deduce the results to which they point, comparing them with practice or the observed results of experience.

It should be a matter of interest with every gentleman who sails a yacht to know and understand, as far as exact knowledge may go, the action and result of the different forces he makes subservient to his pleasure; and while there is perhaps no more complicated problem than a definite statement of every successive cause and effect that results in the flying yacht, still a consideration of the principal forces at work, and how they may be rendered most effective, is not only within the bounds of possibility, but is also comparatively simple, and equally within the reach of the mechanic who builds, the yachtsman who sails, and the physicist who investigates the forces of nature.

Concerning both the shallow and deep draught boat much has been written, but it is perhaps, safe to say that little has been written from a standpoint sufficiently general to be thoroughly impartial; for if not advocating one side of the disputed question to the extreme prejudice of the other, then perhaps, with the view of reaching a certain class of readers, the treatment has been so popular as to be wanting in thoroughness, or, on the other hand, from the standpoint of the physicist all practical considerations have been overlooked.

It will be our purpose to address the general reader, while it is also proposed to view this question in the simple light of a problem of mechanics, and ascertain what may be learned from an analytical yet, if possible, a strictly practical consideration of the subject. To avoid the error incident to a confusion of terms, as well as a misconception of the principles involved, it will be necessary to begin our inquiry with the pure mechanics of the subject, and endeavor to obtain, first of all, clear ideas as to the meaning of certain technical expressions in common use as well as the theoretical and practical value of the quantities they represent.

To do this let us first suppose a body in a fluid of greater relative specific gravity, which is the physical condition of any vessel afloat in the water. In the simple case chosen there are forces at work whose united and resultant action, as in all cases, determines the position the body will assume, *first* with respect to the surface of the water or "plane of flotation," and *second* with respect to its own "axes" and "planes of symmetry," meaning those lines and planes in a body about which its mass is evenly balanced. In practice the vertical plane passing through the stem and stern post is a plane of symmetry, because the mass of the vessel, in any position, is evenly distributed and balanced with respect to it, and in practice it is the only plane of symmetry the vessel contains.

The position which the body finally acquires in the water, when left to itself undisturbed by any external forces, is one of equilibrium, or rest; and this position, under the circumstances named, is in practice obtained where the plane of symmetry of the vessel is vertical, at right angles to the plane of flotation, and the center of gravity of the entire mass is at the lowest possible point. In such a simple case, which is that of any vessel afloat and at rest in the water, certain forces are at work which must be in equilibrium among themselves, or else motion would ensue until a position of rest were reached. As will be seen later, there are various positions of equilibrium, resulting, however, from the action of an external force or the resultant action of many of them, which, together with the first mentioned, bring about a new position of equilibrium. Neglecting for the present any external force, a vessel at rest in the water as described is acted upon by *its own weight*, a force directed vertically downward through the center of gravity of its entire mass. This force will be recognized at once as the entire weight of the vessel, including everything in or upon it.

A reaction against the downward force results. It is the upward thrust of the displaced water, just equal in amount to the entire weight of the floating vessel, and contrary in direction. This upward force is known as the "buoyant effort," and results from the displacement of the water by the vessel settling down into it until a point is reached where the "buoyant effort" is just equal and contrary to the weight of the vessel In this assumed position of rest these two forces are the only ones at work; they are equal in intensity and contrary in direction; holding each other in equilibrium, they produce rest.

The intensities, points of application, and directions of these two forces under different circumstances determine the question of equilibrium or resulting position of all floating bodies.

The forces for discussion will then be:

First.—The weight of the vessel. It is necessarily constant in quantity; its intensity remains always the same, and comprises not only the weight of the hull, but everything in or upon it, masts, spars, rigging, and sails, as well as movable cargo. The point of application of this force, or the point where it acts and its effort is felt, is the center of gravity of the entire mass. Its direction is vertically downward through this point. The force is therefore known, and its effect may be ascertained, for all its elements are given. No matter what the position of the vessel, this force remains invariable in its intensity, direction, and point of application.

Second.—The "buoyant effort." The action of the water to support a body wholly or partly immersed in it is called the "buoyant effort." It acts simultaneously with the first mentioned force; is just equal to it in intensity and contrary in direction, acting upward.

Like the first, its intensity is always constant, because it is always equal to the weight of the displaced water, *i. e.*, the weight of a volume or bulk of water corresponding exactly in shape and size to the submerged portion of the vessel, and comprising a quantity of water, *in whatever position the vessel may assume*, just equal in weight to the weight of the entire vessel with everything in or upon it, and is commonly known and described as the vessel's "displacement." The point of application of this force, however, or the point in the vessel at which it acts, is variable in position, which is very important, for this point moves with every motion of the vessel from side to side of the plane of symmetry, but its position can always be ascertained from any given position of the vessel. All this will be clear from a consideration of the nature of this force. It is always the upward thrust of the displaced water, and, therefore, acts vertically upward through the center of volume or figure of the water displaced, or, what is the same thing, through *the center of volume of the submerged portion of the vessel*, which, of course, changes as the vessel in rolling or careening submerges more of the hull on one side of the plane of symmetry, and removes from the water a corresponding amount (in volume) on the other. It will be clear, however, that as this amount of displaced water must always be the same in weight at all times, the submerged part of the vessel must always be the same in volume or bulk, no matter what its position or configuration. This point, the center of volume of displaced water, will, it is evident, never coincide with the center of gravity of the vessel, but will always be above it, below, or to one side, as the vessel changes constantly from one position to another in rolling about or pitching, and thereby changing the configuration and shape of the submerged part. For any given position of the vessel, however, the point through which the buoyant effort acts can be determined with close approximation.

The second force may therefore be regarded as known, its intensity, direction, and point of application being given.

The point, variable in position, through which this second force acts is called the "center of buoyancy," being the point through which the buoyant effort acts.

The two forces considered being in fact but a single one, the weight of the vessel and the consequent upward reaction the water opposes to it, are the only original forces at work in the system, *i. e.*, in the floating vessel regarded as an independent system of forces. Left thus alone, they produce equilibrium, and the vessel floats at rest.

If the vessel is now subjected to the action of any external force, or many of them, the equilibrium of the first two is at once destroyed, another force is introduced into the system which compounds itself with the first two, and a new position of rest, one in which all three forces are in equilibrium among themselves, must result.

It is this second or new position of equilibrium, the determining circumstances of which are of practical value. We have, then, a third force external to the system of vessel and water which acts upon it combining itself with the forces considered, and producing results dependent entirely upon the new conditions. In practice there are generally a variety of external forces that affect the vessel, but they all have a single resultant, which may be found and treated as a single external force, thus giving definite data to the problem. A moment's consideration of the subject will show that of all the external forces that may affect the position of a vessel in the water, there is always one in practice—the action of the wind—compared with which all others are insignificant in value. For instance, it affects but little the careening force of the wind for a man to walk from one side of a good sized yacht to the other, or how comparatively little does the sudden shock of a wave to windward affect this force! (No reference is here made, of course, to little sailing tubs and cat boats, in which the smallest forces at work compare in magnitude with the larger ones that determine the boat's stability.)

The external force, then, for our consideration at present will be regarded as the assumed resultant action of the wind upon the entire sail area. Its point of application will be at the "center of effort" of that area. The force will be assumed to act parallel to the horizon; but should it not, it could be resolved into components, horizontal and inclined, of greater or less relative value according to the inclination of the sails and the direction of the wind with respect to their surface (assumed flat).

This horizontal component, in most cases the actual force of the wind, careens the yacht, while the inclined one acts parallel to the surface of the sails, and its effect is lost.

This third or external force completes all those involved; others of course arise, but their action is comparatively insignificant. The point of application of this external force is known. Its intensity is also known, being so many pounds pressure to the square foot of sail exposed, depending upon the velocity of the wind, and directed at a certain inclination to the sail area. To simplify the discussion, its direction will be assumed horizontal and at right angles to the longer axis of the vessel, or practically abeam. No matter

what direction the wind comes from with respect to the vessel, it will have such a component, susceptible of measure with greater or less approximation; and it is this component whose action when combined with the other two it is desired to investigate, and ascertain what new conditions of equilibrium arise and what arrangement of the first two forces is best calculated to meet and resist the action of the third.

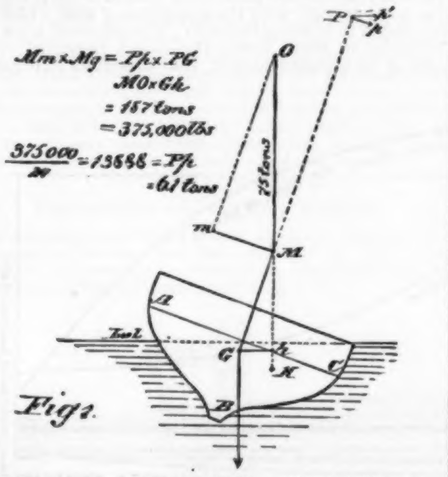
The foregoing statement of the forces and principles involved is perfectly general in character and equally applicable to all cases, and must determine the position under given circumstances of any vessel afloat, whatever its shape, size, or mass.

The question of the relative stability of two yachts consists, then, in the determination of the resultant or ultimate action of all the forces at work, internal and external, under the same circumstances for each. The question involves also in a measure the determination of how, under given circumstances, the action of any external force, as the wind, may be best met and resisted, or used, by the combined action of the known interior forces at work.

The external force will of course have to be assumed. It is necessarily the resultant of several, each of which depends for its direction and intensity upon a variety of data, which can only be approximated in value.

To explain the action of these forces, let Fig. 1 represent the cross section of a yacht in which A, B, C, is the immersed portion of the midship section when at rest on an even keel. Let the center of gravity of the entire vessel be at G, in the section taken. Let the center of volume of the submerged portion in the inclined position indicated be at H, which point is the center of buoyancy, and the center of gravity of the displaced water. It is the point through which in the position assumed the upward thrust or resistance of the water acts. This point of course may or may not be in the cross section taken containing G, but it may be there, and it will simplify the discussion without in any way affecting the results to assume such a position of the yacht as would bring G and H into the same midship section.

Now it is apparent that when the yacht is careened as shown in the figure, its entire weight still acts downward through G, while the resistance opposed by the displaced water acts vertically upward through H.



These two forces produce a tendency to rotation as a result of their combined and simultaneous action, one pulling down through G, the other pushing up at H, and both acting on the rigid form of the boat. The effect of the two, since they are equal in intensity, is to produce a tendency to rotation about a point midway between them, and by which the vessel seeks to regain a position of equilibrium on an even keel, and manifestly requires the action of a third or exterior force to hold it in the inclined or careened position.

From a simple principle of mechanics we know that this tendency in the boat to return to the vertical position is measured by what is known as the "*moment of rotation of the couple*," which is equal to the product obtained by multiplying either force of the couple by the perpendicular distance between them.

Considering the vessel free in the water, it can be shown that for slight changes of position, such as arise in practice, the vessel will careen by turning about its center of gravity, G, which will always retain its position with reference to the low water plane, or plane of flotation, unchanged.

The tendency to return to the vertical from the careened position may therefore be put in a somewhat simpler form for our use, for in view of the principle first stated, the moment of the couple becomes equal to the product of the force acting upward through H, which is the displacement, or what is the same thing, the entire weight of the vessel (so many tons or pounds) multiplied by the *horizontal* distance between G and H; or in other words, the tendency to return is measured by the force acting upward through H, and with *a lever arm* equal to the horizontal distance from G to H, indicated in the figure by the line, G *h*. Now the force acting downward through G may be neglected.

The question of stability consists in determining the value of this force acting with the various lengths of "lever arm" that may arise, and ascertaining for given lengths how great an external careening force in the form of wind acting abeam it is calculated to resist.

The line, G P, through the center of gravity of the vessel, and which is vertical when the vessel is at rest on an even keel, is called "*a line of rest;*" it is the line along which the weight of the vessel and the upward thrust of the displaced water act in opposite directions, and hold each other in equilibrium, when the vessel is in that position (vertical) and subject to no external force. The moment the vessel careens, the "center of buoyancy," H, through which the buoyant effect of the water acts, moves out of this vertical line to the right or left, the two forces no longer oppose each other directly in the same straight line, but their points of application become separated while their directions remain parallel, and a "couple" results. This *new* vertical through H, along which the buoyant effect acts, is called "*a line of support*" because it is the line along which the water supports the weight of the vessel partly submerged in it.

As the point, H, is the point at which the buoyant effort of the water acts, it must be the center of volume (or bulk) of the displaced water; and the position of this point depends evidently upon the shape and configuration of the submerged portion of the vessel, and it is clear that as the vessel whose cross section is given in the figure careens more and more to the right, it submerges more and more of its hull to the right of the line of rest (or plane of symmetry), G P, and takes more and more of its bulk out of the water to the left of that line (or plane). It is therefore apparent that the center of volume of the submerged part, or the point, H, must travel more and more to the right as the vessel careens, and thus increase the distance, G *h*, as the vessel continues to turn over. Now the point, M, in which the line of support, H M, cuts the line of rest, P G, is called the "metacenter" of the vessel. Its position in the vessel is important, for it will be seen from an inspection of the figure that the vessel cannot capsize, but will have a tendency to return to the upright position so long as the metacenter is above the point, G, the center of gravity.

This results from the fact that the metacenter, M, may be regarded as the point through which the upward thrust of the displaced water (acting first through H) is brought to bear upon the line G P, where the careening force is applied (say at P). In other words, G M may be regarded as the lever arm with which the buoyant effort seeks to right the vessel, acting through M at right angles to G P, and with the intensity M *m*; that component of the "buoyant effort" which acts at right angles to G P and in opposition to the careening force at P, indicated by P *p*. It is therefore evident that the higher M, the metacenter, is above G, the greater will be the lever arm, M G, and the greater the advantage with which the buoyant effort seeks to right the vessel. It is for this reason that the height, M, of the metacenter above the load-water plane (or plane of flotation) is considered an important factor in yacht construction.

Let us now suppose the action of a third or external force brought to bear at some point, as P, on the line of rest, and acting in the direction, P *p'* (horizontal), and whose tendency is exerted to careen the boat to the right.

Under its action the boat will turn about the point, G, its center of gravity, and it is evident, from a consideration of the figure, that this external force, whose intensity is indicated by the length of the line P *p'*, acts with its entire value to careen the boat only when the line of rest, G P, is vertical, for as the vessel careens under the action of this force, its effective component P *p*, perpendicular to P G, becomes constantly smaller in proportion as the careening angle P G R increases; and at the same time, while the actual careening force P *p*, the perpendicular component of P *p'*, is becoming less and less as the vessel careens the point H is going further and further from G; the metacenter M further and further up the line of rest P *b'*, thus increasing the lever arm of the buoyant effort and at the same time increasing its effective component, M *m*, which resists P *p*. It is therefore apparent that an angle will soon be reached at which the buoyant effort, acting upward through H and transmitted to M (and there, we will say, acting at right angles to P G in the direction M *m*), will hold the careening force acting through P in the direction P *p*, in equilibrium, and the boat will come to rest in an inclined position of equilibrium, and cease to careen. This position will be readily recognized by those familiar with sailing.

The graphical construction of these forces is simple, and will perhaps add clearness to the demonstration.

Prolong H M to O, assume a scale of equal parts in which a unit of length shall represent a given number of units of force, say five tons to the quarter inch (or any convenient scale), make M O equal to the upward thrust through H so many tons (the displacement of the vessel expressed in units of length). Resolve M O into its components by means of the parallelogram of forces acting in the direction G P and at right angles to that line. M *m* will be this component; so many tons or pounds acting in the direction M *m* through the point M with the lever arm M G and urging the boat to the left about the point G.

The force P *p'* acting at P is the force of the wind on the entire sail area, so many pounds per square foot (depending on the velocity of the wind) for so many square feet. This entire force is laid off on P *p'* with the same scale of equal parts indicating so much force to the unit of length. P *p'* is then resolved in like manner into its components acting along G P and at right angles to it. P *p* is the remaining effective component of P *p'* that acts at P to turn the boat about G to the right, in opposition to M *m* acting at M to the left. The greater force has necessarily the shorter lever arm, the lesser force the longer; both have the point G as a center of action. From the expressed conditions we must therefore have:

$$\mathrm{P}\,p \times \mathrm{P\,G} = \mathrm{M}\,m \times \mathrm{M\,G} \qquad \text{(Eq. 1.)}$$

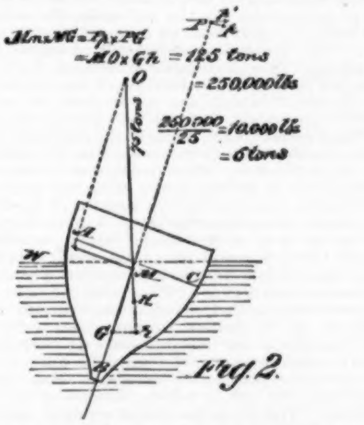
In a position of equilibrium the two rectangles having M *m* and M G, and P *p* and P G for sides respectively *must be equal in area*, which is the geometrical interpretation of the equation of condition.

Having thus briefly determined the new conditions of equilibrium under the action of a single given external careening force, or a number of such forces having a single resultant, we find its moment of rotation or tendency to capsize the boat counteracted and resisted by a moment of rotation in the opposite direction produced by the buoyant effort of the water acting upward through H, and we conclude from the preceding that the careened position of equilibrium will be soonest reached by making the first number of equation 1 small, *i. e.*, the product P *p* × P G; but P *p* depends for its value upon the effect of the wind, manifestly beyond our control, while P G represents the distance of the center of effort of the entire sail area (where the wind acts) above the center of gravity of the vessel, but the position of this point P is fixed by the shape of the sails. It therefore seems that instead of making the first member of Eq. 1 small, we must seek to make the second member relatively large; we must try to make it so large that, for a given value of P G, P *p* may have any possible value, without incurring the danger of their product exceeding the product of M *m* × M G. We have therefore to ascertain how the force acting upward through H may give the greatest possible product of lever arm M G multiplied by the intensity M *m*.

It is clear from an inspection of the figure that this product depends first upon the upward thrust through H, which must remain constant in intensity, being equal, as we have seen, to the weight of the vessel, and secondly upon the lever arm, M G, with which it acts; in other words, the only way in which we can effect the value of the product which constitutes the second member of our equation, to increase it, is to increase the lever arm, M G, or increase the distance of the "metacenter, M," above the center of gravity, G. But it is evident that this may be accomplished in two ways, viz., we may either lower the position of the point G on the line P G, which means simply to make the center of gravity of the vessel very low and deep by using a lead keel or much ballast, or we may move the point M higher up by causing the point H to move rapidly to the right of G as the vessel careens, which in turn means to give the vessel a broad and shallow cross section, so that the "center of buoyancy" in the careened position will be very far to the right of G, thus causing the line of support H M to cut the line of rest P G at a point high up above G. The latter method amounts virtually to increasing the line G *h*, which is the horizontal distance between the two centers, and it is evident this may be effected either by lowering the position of G on the line P G, or by carrying H to the right. Either way will answer so far as the theory of the matter goes; both are used in practice with good results, as we shall see.

It is clear that by making the cross section of the vessel narrow and deep, and hanging a lead keel on the bottom, we are in fact bringing G to its lowest possible point below the load-water plane, and are using the first of these methods. But if, on the other hand, we leave the position of the center of gravity, G, out of consideration, and make the cross section of the boat, A B C D, broad and shallow, the point H will move rapidly to the right as such a vessel careens, and thus rapidly extends the line G *h* to the right of G and raises the point M on the line P G, thus increasing the lever arm of the force M *m*.

These two methods of increasing the factor M G in equation 1 give us at once the principles of mechanics that underlie the deep and narrow cutter on the one hand and the broad and shallow sloop on the other. Thus are we brought in theory, by analytical investigation of the forces at work, to the same identical issue



that the whittling mechanic has brought our practical knowledge of yachts through years of experiment.

The analytical deductions show clearly that we may elect either of these two methods to produce the desired result.

Bearing in mind the action of the different forces considered, we may proceed further to investigate the relative advantages the two methods present under given conditions in practice.

The first, with low center of gravity and narrow beam, is the usual model of the English cutter, the latter that of the American sloop. It will be seen that they differ essentially in principle, and, as might well be expected, each has both advantages and faults peculiar to its class.

Fig. 1 is a fair representative of the American sloop in cross section, while Fig. 2 represents the cutter type. In order to make our consideration of these two forms as conformable to practice as possible, the two figures with the necessary construction are drawn to scale, and represent the corresponding elements of two boats having the same load-water line length, same displacement, and the same sail area nearly. The principal remaining elements are given below:

	Sloop.		Cutter.	
Length, L. W. L........	65	feet.	65	feet.
Beam (extreme)..........	15	"	11½	"
Draft..................	9	"	12	"
Lead on keel............	3	tons.	38½	tons.
Lead inside.............	33	"	1½	"
Ballast, total...........	36	"	40	"
Displacement............	75	"	75	"
Mast (deck to hounds)...	41	feet.	42	feet.
Main boom...............	52	"	58	"
Gaff....................	35	"	39	"
Bowsprit outward.......	27½	"	30	"
Area lower sails.........	3,000 sq. ft.		3,450 sq. ft.	
Custom House bulk.....	44 tons.		40 tons.	

The center of effort of the sail area in each (lower sails only) would be about twenty-five feet from the deck, *i. e.*, the point P at which the wind acts in both. The displacement of both boats is 75 tons, or 150,000 pounds; this is the measure of the upward thrust or buoyant effort of the water in each. Let us suppose them both careened to the same angle as indicated in the figures, and ascertain the corresponding resistances afforded in each to a careening force acting through the point P to the right. The submerged portion in each cross section now becomes *a* C *b*, but it will be readily seen that in this position the excess of the submerged portion of the boat on the leeward side of the line of rest G P over that to windward is far greater in the sloop (Fig. 1) than in the cutter (Fig. 2), and that the center of volume of the submerged part (H) in the sloop is

necessarily, on this account, much further removed to the right of G than in the cutter.

To offset this, however, the position of the point G in the cutter (the center of gravity of the entire mass) is considerably lower down on the line of rest P G than in the sloop, owing somewhat to the shape, but chiefly to the lead keel the former carries, and this in a measure compensates for the small movement on the point H (the center of buoyancy) to the right in the case of the cutter.

As G represents very closely the position of the center of gravity in each case, so H also represents with little error the corresponding position of the center of buoyancy in the two types when both are careened to the same angle. It will be observed, however, that the distance G *h*, is considerably greater in the case of the sloop, and that the position of the metacenter, M, is consequently much higher.

In the careened position chosen we have in each case 75 tons = 150,000 lb., the buoyant effort or displacement of both boats, multiplied by the corresponding distance G *h* = 2$\frac{5}{10}$ feet for one and 1$\frac{66}{100}$ in the other, which for the sloop gives 150,000 × 2½ = 375,000 lb. = 187 tons, and for the cutter 150,000 × 1⅔ = 250,000 lb. = 125 tons, for the measure of the "moments of rotation" due to the upward thrust of the buoyant efforts acting along the lines of support H M, and tending to right the vessels by turning them to the left about the point G in each.

The distance G P in the cutter will be say 25 feet and in the sloop 27 feet, the cutter having a low and long sail plan, as shown by the dimensions given, and the sloop a higher and shorter one (this of course considering the lower sails only, mainsail and jib). The center of effort being in each at the point P, and dividing the respective moments of rotation by the distance G P, the "lever arm" with which the careening force acts in the two models, we get for the sloop 375,000 ÷ 27 = 13,888 lb. = 6$\frac{1}{16}$ tons, and the cutter 250,000 ÷ 25 = 10,000 lb = 5 tons, which represent in each case the resistances that the internal forces are calculated to oppose to a careening force acting at the point P and at right angles to G P.

Let us suppose the sail areas in each case, or means of meeting the careening force at P, equal or 3,000 square feet for both cutter and sloop, we have as a result 4½ pounds pressure to the square foot of sail exposed in the sloop, and only 3⅓ pounds for the cutter, to careen both to the same angle; but as these forces are supposed to act perpendicular to the sail areas, the actual force of the wind in each case to accomplish the same result under the conditions given will of course be greater.

Making, then, a suitable allowance for the inclination *p* P *p*, and the inclination of the sail to the beam of the vessel (which are never flat), these pressures would correspond to wind velocities of 30 and 35 miles per hour respectively, being in the ratio of 6 to 7 for cutter and sloop.* We therefore see that for a given careening angle the sloop offers considerably more resistance to the wind or driving power than the cutter, or, what is the same thing, in a given amount of wind the cutter will careen more than the sloop, or in common parlance the sloop is a "stiffer boat;" other conditions being equal, she will stand up to the wind† better; but not only this. It follows also as a matter of course that, as the wind force acting at P to drive the boat has its effective component, P *p*, diminished rapidly as the boat careens, the component perpendicular to the sail alone being available for this purpose. It therefore follows that in standing up to the wind the sloop is enabled to use a greater portion of the entire actual force of the wind than the cutter, which careens more for a given amount. The sloop has therefore more driving power for a given spread of canvas, and the cutter must carry more sail to get the same amount of propelling force.

At the same time, and for the same reasons, the cutter will doubtless stand a heavier blow with less danger of disastrous results than will the sloop, which, being stiff, will not yield beyond a given point to the gale, and is liable to lose sail or spars, while the cutter will be hove down to her beam ends, where the careening power of the wind becomes greatly diminished, but she will still be in a position of stable equilibrium, and slowly right herself as the wind ceases. A consideration of the two figures and a similar construction of the forces at work in different positions will make this clear.

For considerations of speed, however, in a wind that both can stand up to under full sail, the mechanics of the problem seem to be decidedly in favor of the sloop, whose broad beam enables her to use and derive more actual driving power from a given velocity of wind. The cutter, being hove down considerably in a moderate wind, loses much of the effective force.

Where, then, it will be asked, does the question of relative speed come in, as every one familiar with yachting knows that the cutter often rivals and sometimes beats the sloop in time. The answer is simple, but not of easy demonstration; in fact, it is not analytically demonstrable at all. The cutter often beats the sloop under given conditions, and the reasons for this are so complex as not to be within the bounds of exact mathematical investigation.

In a few words, the answer may be stated in general terms that the cutter, being narrower and sharper, has less resistance to overcome in moving through the water, and so compensates for other defects; but for the mere physicist it is no answer to say that when the cutter beats she does it because she goes faster, and that she goes faster under certain circumstances because she goes easier. We cannot hope to explain the matter on demonstrable grounds. The facts of the case, as yachting statistics show, are that the cutter rarely beats the sloop under like even conditions so near as they can be attained, and the results of practice seem to have fairly maintained the slight difference the theoretical principles show in favor of the sloop. The mechanical principles involved seem to incline decidedly in favor of the sloop, and practice has in the long run left but little question of their relative merits under the same conditions as regards speed alone.

Ever since yachts have been sailed the question has always been an open one, and both sides have strong advocates, mainly because the conditions under which the two types have been developed seemed to require the advantages peculiar to each.

Wherever the principles that underlie a problem of mechanics point, as in the present instance, to two solutions, the two methods of arriving at like results will always be found adapted to different conditions that are likely to arise in practice, and the experience of years shows this to be exactly the case in the present instance.

Referring to the figures again, we see the sloop, whose chief excellence is due to her breadth of beam and consequent stiffness combined with light draught, is in every essential feature a smooth water craft; she is evidently designed to skim over the surface of the water rather than to plow through it, while the cutter is just as evidently designed for rough water, and is essentially a sea going craft.

The sloop has indeed great stability, but she is at the same time a quick, jerky boat; the "metacenter" rises and falls rapidly as the boat careens a little more and then returns to its former position; she rights herself suddenly at the least slackening of the wind, and is comparatively ill adapted to a heavy sea, while the cutter, owing to the slight change the center of buoyancy undergoes in moving from one careening angle to another, is necessarily a much easier sea going boat. She goes over on to her beam ends with perfect safety, and returns easily and gradually when the wind slackens. The same kind of reasoning applies again to the sloop, whose windward side, lifted high out of water, is subject to heavy shocks and jars from waves which are likely to impede her progress considerably in a heavy sea, while the cutter, with her straight lines, rides them easily with less change of position, or plunges through them. It would seem therefore natural under the circumstances and the principles involved that the cutter should be the preferred yacht with the English, who do their sailing so much at sea, and in the rough and choppy waters of the two channels, while with us the centerboard type, more or less modified, for contrary reasons should find preference.

The question can be never definitely settled for all cases; each will always possess merits for the particular situations to which it is best adapted.

Viewed, however, in the light of mere racing machines, the question changes somewhat, as the issue then becomes one of speed alone under the same conditions for both, and from this standpoint there seems to be much in favor of the sloop against the cutter.

Speed will be the sole point at issue in the coming international race, and it would seem, certainly from theoretical data at least, that the Americans have every reason to look with confidence for the best results from their own peculiar type of boat, the centerboard sloop.

In the coming race the cutter is expected to make up for other shortcomings by her narrow beam, consequent straight lines, and low resistance to motion through the water. To offset this, however, it should be borne in mind that she is much deeper than the sloop, and that pressures (in the water) increase in proportion to the depth, and as a result of which there is probably but little gained by the narrow beam which a sloop of moderate beam and light draught, such as the one being built by Mr. Smith to meet the Genesta, will probably be broad enough to skim over the surface of the water with comparatively light draught, and yet be sufficiently narrow to have easy lines and a comparatively low resistance to motion through the water.

The mechanics of the problem seem certainly to favor such a boat. The Figures 1 and 2 show practically the relative midship actions of Commodore Bennett's boat, designed by Mr. Smith, and Lieutenant Henn's cutter yacht, the Genesta, doubtless the best of her type afloat. We have looked into the mechanics of the question, where we have found that the practical yacht builder has already given us all that theory can show, and all this with a shrewd guess at the best way to overcome the resistance that water opposes to motion. Let us, for conclusion, assume his standpoint, and look at nature.

Nature has given us two types of locomotion in or upon the water, by which we may always pattern without being far out of the way. They are the fish and the duck, and the two types of yacht we have considered are in no small degree exponents of these two types of least resistance; but it will not be claimed by any one that a yacht should sail under water or nearly so, and the most enthusiastic will prefer as a rule the type that skims over its surface. The swimming fowl has, so to speak, a broad load-water plane with light draught, its immersed section at the forward end being almost a perfect parabola; and the load-water plane of the shallow American sloop is not unlike it in plan, the chief difference being in the point where the propelling power is applied. The cutter resembles in some respects the fish, with its narrow and deep cross section and easy lines, with the propelling power equally out of place. But here the comparison ends, for though designed to offer but little resistance to motion, the elliptical cross section of the fish is doubtless mainly designed to resist severe pressures at great depths.

The question so far as the yachts are concerned, will doubtless ever remain one of expediency. What do you want to do? will always be the question. Do you wish to ride out a sea without losing a spar or rag of canvas, or do you wish to hurry at any cost over a bit of easy water on a bright September day?

For the former we prefer the cutter type; but if it is a question of keeping the "cup" merely, and there is any virtue in mechanics, we prefer the American sloop—moderate beam, light draught.

F. J. PATTEN.

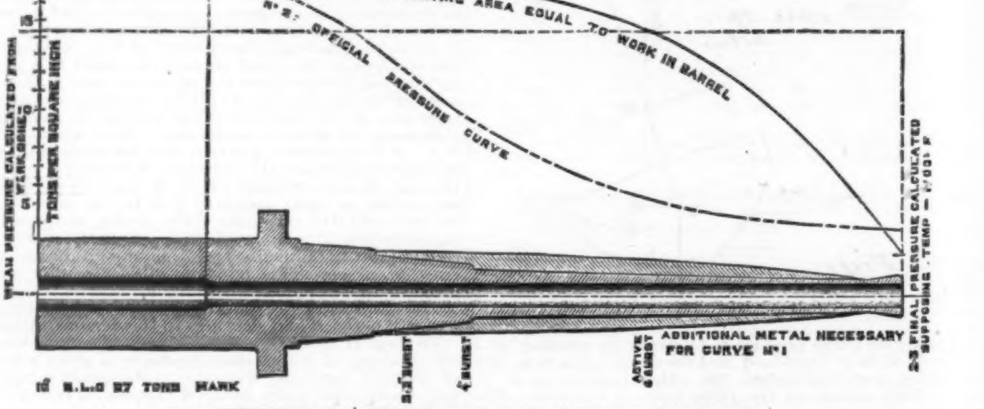
* A table of wind velocities is given below, showing the relative value of these forces.

† Velocity and force of the wind:

Miles per hour.	Pressure pr. sq. ft.	Description of wind.
2 to 3	0·02 to 0·04	Just perceptible.
6	0·18	Gentle, pleasant wind.
20	2·00	Stiff breeze.
25	3·1	Very brisk.
30	4·5	High wind.
35	6·1	High wind.
40	8·0	Very high wind.
45	10·1	Gale.
50	12·5	Storm.
80	32·0	Hurricane. —*Haswell.*

GUNS AS HEAT ENGINES.

MR. W. ANDERSON lately delivered a lecture on "The Conversion of Heat into Useful Work," at the Society of Arts. The greater part of the discourse was devoted to the analysis of the discharge of cannon. The object of the lectures has been mainly to show that the laws of Carnot apply to heat engines, whatever form they may take, and a gun, according to Mr. Anderson, is the simplest form of heat engine. The lecturer began by showing that the properties of gunpowder considered as fuel were known, thanks to the researches of Sir Frederick Abel and Captain Noble; and as the powder gases worked between temperatures which could be defined with tolerable exactness, he showed that the maximum duty to be expected was only 51 per cent., and obtained a value in heat units for which the gun could be made debtor. On the credit side of the balance-sheet which he constructed, he grouped the expenditure of energy under two heads, that producing external work, having a counterpart in recoil, and that doing internal work self-contained in the gun, and producing no visible external effect. He showed that the external work formed 94 per cent. of the total energy, with the exception of that which was expended in heating the gun. The external work was made up of three items: the energy imparted to the shot in its forward motion, that absorbed in expelling the powder gases, and an insignificant item in the displacement of the atmosphere. The first and third items could be ascertained with accuracy, but the energy expended in expelling the powder gases was, up to the present, unknown, and was probably much more serious than was generally admitted.



MR. ANDERSON'S AND OFFICIAL CURVES OF POWDER GAS PRESSURES.

Mr. Anderson next pointed out that recoil consisted of two parts: first, a very short space in which the gun and carriage attained their maximum velocity and energy; and secondly, the part in which that energy was again absorbed by the resistance applied to control the motion. Because the motion of recoil was accelerated, an impressed force must be acting during the whole time of acceleration, and that force was the pressure of the powder gases on the breech-block, so far as it corresponded to the pressures producing external work. The accelerating force was only in action so long as the shot and powder were being expelled from the gun, and therefore the time of getting up the full speed of recoil would be the same as the time of discharge, and not only so, but each change in the velocity of recoil would correspond to a change in the pressure upon the gun; hence he showed that if an accurate diagram of the velocity of recoil could be obtained, a curve of pressures producing the velocities could be constructed, and these pressures would have their counterpart in the chase of the gun. He explained the Sébert velocimeter, and illustrated its action and the curves it produced by means of a pendulum which traced wave lines on a strip of paper moved at various rates of speed; and, taking the new 10 in. B.L.R.G. as an example, he worked out a pressure curve from supposed observations on recoil. The reasoning throughout appeared conclusive, and none the less so because the pressures arrived at were at variance with the indications of the crusher gauges. Mr. Anderson remarked that, in all changes of form caused by external forces acting on metals, time was an element which could not be neglected, and therefore crusher gauges to be trustworthy should either be exposed to pressure long enough to take their complete set, or else they should be exposed for the same time as when tested. As this was impossible, the inevitable conclusion was that the indications were too low, and more erroneous in this respect in the muzzle than in the chamber. In confirmation of this view, he cited the remarkable coincidence between the indications of the crusher gauges and the pressures derived from the known accelerated motions of the shot only, which, of course, left out of account all the other sources of pressure enumerated in the balance sheet,

and which formed 40 per cent. of the whole; hence, the crusher gauges might be erroneous to that extent.

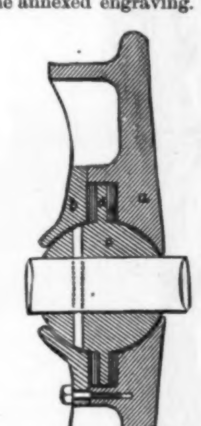
Whatever may have been in the lecturer's mind, he made no allusion to the strength of the new pattern guns which are being manufactured at Woolwich; but it is impossible to examine the pressure curve traced along the 10 in. gun, and not be struck with the evident weakness of the weapon from the trunnion outward, and this conviction is further increased when we compare it to the official pressure curve, which is supposed to indicate pressures equal to one-fourth the bursting strains. The discrepancy between Mr. Anderson's curve and the official one is greatest between the trunnion ring and the muzzle; and here it is that most, if not all, of the new guns have burst. The sketch we annex is taken from Mr. Anderson's diagram, to which we have added the official curve. The lecturer remarked that the pressure curve was really an indicator diagram of the gun; its area represented the work done. We make out that the official diagram will not even account for the energy imparted to the shot, and it must therefore be as wrong as the crusher gauges, upon the indications of which, we presume, it must have been constructed.

It seems difficult to imagine that the War Office cannot find men competent to investigate the important questions raised by Mr. Anderson. It is clear that the present Ordnance Committee is unequal to the task. They have had every opportunity of arriving at the data necessary to design guns with certainty as to the results, and yet they issue indicator diagrams attached to the official drawings which must be grossly erroneous. We feel convinced that guns made with a proper factor of safety throughout will not need any very special material in their construction, seeing that good guns have been made of materials so various as cast iron, brass, iron, and steel, and may be spared all the cooking in oil and tallow which now seems to be the only means thought of for insuring sufficient strength. The recent experiments instituted for solving the supposed mystery of the failure of the Active's gun have shown that the pet theory about obstructions is untenable; and we trust that the plain truth will be at once confessed that the guns are too weak, that they have been designed on utterly erroneous data, and that Mr. Anderson's method of arriving at the true pressures will be resorted to without delay, and, if possible, with his assistance.

In the sketch we have thickened up the metal in the parts which are known to be weak, and have made them what they should be according to Mr. Anderson's views. Much stress has been laid on the circumstances that the Active's gun burst with a half charge; but surely competent mechanics do not need to be told that once a structure has been repeatedly overstrained, it may fail at any time with loads much smaller than those it had frequently carried.—*The Engineer.*

TENWICK'S SWIVELING WHEEL.

AN automatic swiveling wheel, specially designed for tramcars and corves, has been devised by Mr. John Tenwick, of Spittlegate, Grantham, England, and is illustrated in the annexed engraving.



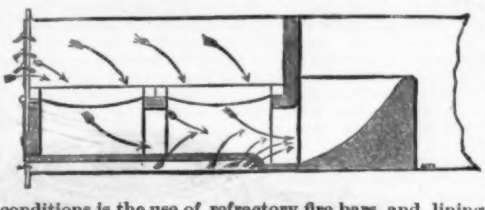
The wheel, *a*, is secured to the axle by a kind of ball and socket joint, which allows the wheel a certain amount of play in passing around curves; by this device an effect is gained which is somewhat similar to that produced by the use of radial axle boxes. The ball, *c*, is fixed to the axle by a steel pin, and has a flange, *d*, all around it. This flange lies between two India rubber washers in a recess formed in the body of the wheel, *a*, and covered by the cap, *b*. Messrs. Jessop & Co., of Sheffield, are the manufacturers, and we are informed that the wheel has given great satisfaction where it has been tried during the last twelve months. The elastic washers insure its coming back to its normal position immediately the curve is passed, and prevent sideways oscillation of the vehicle.

SMOKELESS FURNACES.

WELFORD'S smokeless system of furnaces is based upon the employment of two supplies of air, the first to burn the carbonaceous or solid portion of the fuel and the second to burn the gaseous portion. To insure the essential conditions of perfect combustion the first portion of air is caused to pass down through the fuel and through a grate formed of refractory bars, and then the product of this primary stage is passed into the ashpit, which is lined with refractory material to maintain the temperature, so that when the second supply of air is admitted at suitable openings in this ashpit, it completes the combustion of the gaseous portion of the fuel. The resultant hot gases are next sent through a regenerator, to give time for diffusion, after which they come in contact with the heating surfaces of the boiler. The object of using refractory material is that it is non-absorbent, and prevents the cold boiler plate at these points from cooling down the gases, as this would in itself form smoke, and cause great waste of fuel.

The illustration shows the invention applied to a Cornish boiler. The fuel is burnt upon a grate of fire-brick bars, and the air, which enters through Venetian shutters in the fire door, passes downward through the incandescent fuel, carrying with it the gases driven off from the top layer of coal. Below the bars, and occupying the position of the ordinary ashpit, is a brick-lined combustion chamber, to which air is admitted at the far end, just behind the bridge, which is formed of a honeycomb of bricks, not shown in the engraving. The air and gases enter into combustion, and the flame passes up through the bricks into the boiler flue.

By this system the necessary quantities of oxygen are supplied at the proper times and temperatures to the carbon and hydrogen of the fuel. One of the main



conditions is the use of refractory fire bars and lining of ashpit, in combination with down draught, to give and maintain the necessary temperature to effect complete combustion.

INLAND NAVIGATIONS IN EUROPE.

THE fourth of the course of special lectures on "The Theory and Practice of Hydro-Mechanics" was lately delivered at the Institution of Civil Engineers, by Sir Charles A. Hartley, K.C.M.G., M. Inst. C. E., the subject being "Inland Navigations in Europe." The chair was occupied by Sir Frederick J. Bramwell, F.R.S., the President.

The lecturer premised that his professional experience being mostly in connection with the great rivers of Continental Europe, his remarks on the inland navigations of Great Britain would be brief. The lower parts of the chief rivers of the United Kingdom were mostly arms of the sea, navigable at high water by ships of the largest burden. The principal waterway, the Thames, was navigable for about 194 miles, and was united by means of a grand network of canals with the Solent, the Severn, the Mersey, the Humber, and the Trent, being thus in direct communication, not only with the English and Irish Channels, but also with every inland town of importance south of the Tees. Other river and canal navigations were briefly noticed, among them Telford's masterpiece, the Caledonian Canal, and the estimated length of inland waterways in the United Kingdom was given at 5,442 miles, which had been constructed at a cost of £19,145,866.

Turning to the Continent, Russia next claimed attention as having the greatest extent of water communications. Its principal highway was the Volga, the largest river in Europe, which, in a course of more than 2,000 miles, drained an area of 563,000 square miles, and afforded, with its tributaries, 7,200 miles of navigation, but of very unequal capacity, owing to the shallow depth of some portions.

Hitherto, no permanent works had been undertaken to improve the navigation of the Volga, but dredging had been resorted to in the lower part of the stream, and recently a system of scraping by iron harrows had been employed, which was stated to have doubled the depth of water over certain shoals in a few days. In the lecturer's opinion, the Russian Government would hesitate a long time before embarking in costly improvement works, the effect of which would be very uncertain. Other important water communications in Russia were the Caspian, an inland sea of 160,000 square miles extent; the River Don, 980 miles in length, and draining 170,000 square miles; the Dnieper, draining 204,000 square miles, and with a course of 1,060 miles. Of secondary rivers, the Bug, the Dniester, the Duna, and the Neva were all navigable; in the case of the latter short, but most important, means of communication, a maritime canal eighteen miles in length had recently been completed to unite Cronstadt with St. Petersburg. About 900 miles of canals had been constructed in European Russia. In most instances they had been formed with but little difficulty, across the gentle undulations of the great watershed, the object being to connect the head-waters of rivers which had their outlets at opposite extremities of the Continent.

Sweden abounded with lakes, which covered more than 14,000 square miles of its surface, but none of the rivers were navigable except those which had been made so artificially, nearly all of them being obstructed by cataracts and rapids. Nevertheless, Sweden possessed remarkable facilities for internal navigation during the seven months that the country was free from ice, intercourse being carried on by means of a series of lakes, rivers, and bays, connected by more than 300 miles of canals. Of the latter, the most celebrated was the Gotha Canal, designed under the auspices of Count von Platen, by Telford, the first President of this Institution.

Germany owned parts of seven river valleys and three large coast streams, viz., the Niemen, the Eyder, the Vistula, the Pregel, the Oder, the Elbe, the Weser, the Ems, the Rhine, and the Danube. Of these the Weser was the only one which belonged wholly to Germany, while of the Danube but one-fifth part ran through her territory. The hydrography of all these rivers was briefly described. The inland navigations of Germany were of the most advanced character, an immense trade being carried on upon them by means of barges and rafts. In the case of the Elbe, the system of towing by submerged cable had taken a large development. As early as 1866 chain-tugs were running on 200 miles of its course, and in 1874 this mode of traction had been so increased that there were then twenty-eight tugs running regularly between Hamburg and Aussig. These tugs were 138 ft. to 150 ft. long, 24 ft. wide, with 18 in. draught. On the Upper Elbe the average tow was from four to eight large barges, and, taking the ice into consideration, there were about 300 towing-days in the year. It was found that large vessels paid best; thus, in the case of the Hamburg Magdeburg Navigation Company, the cost of transporting a cargo from Hamburg to Dresden—a distance of 350 miles—for barges of 150 tons, 300 tons, and 400 tons, was respectively 11s. 6d., 9s. 9½d., and 9s. 4d. per ton up stream, and 4s. 4½d., 3s. 2½d., and 2s. 9½d. per ton down stream. Although Germany possessed a length of nearly 17,000 miles of navigable rivers, or more than double the combined length of the navigable streams of the United Kingdom and France, it could not be said to be rich in canals. In South Germany the Regnitz and Ludwig Canals, from the Main at Bamberg to the Danube, were the only ones of importance until the annexation of Alsace-Lorraine. The North German plain had several canals, the most important of which were referred to in the remarks on the chief river systems of the empire. In 1878 the total length of the seventy canals of Germany was only 1,250 miles, a very small extent when compared with the other canal systems of Western Europe.

Holland possessed the great advantage of holding the mouths of the Rhine, the Maas, and the Scheldt. Her means of river communication with Germany, France, and Belgium were unbounded, and the possession of a length of 930 miles of canals and 340 miles of rivers enabled her, apart from her railways, to carry on her large trade with greater facility of transport than, perhaps, any other European country. One of the principal artificial works in Holland was the North Holland Canal, constructed by Blanken in 1819–25, at a cost of nearly £900,000, and esteemed the greatest work of its day; it was 52 miles long and 18 ft. deep. It had now been almost superseded by the Amsterdam Canal, constructed by Sir John Hawkshaw, and of which a detailed account was to be found in the Minutes of Proceedings.

Belgium shared with her northern neighbor the advantages of an elaborate system of waterways. The principal were the Meuse and the Scheldt. The total length of the Meuse, which was canalized at difficult places, was 580 miles, of which 460 miles were navigable. But by far the most important river of Belgium was the Scheldt. Thanks to its unique position at the head of a tidal estuary, to the abolition of the Scheldt dues, and to the foresight and liberality of the Belgian Government, which had spent £4,000,000 on dock and river works since 1877, Antwerp had now become in many respects the foremost port of the Continent. Besides her 700 miles of navigable rivers, Belgium possessed about 540 miles of canals, by means of which communication existed between all the large towns and chief seaports of the kingdom.

France had built up, and was constantly extending, an elaborate system of canals and canalized rivers. Of the latter the Seine was the most important in regard to the artificial works undertaken for its improvement, and for the tonnage of the traffic, which was in 1872 more than one-eighth of the whole waterborne traffic of France. The lecturer successively passed in review the Loire, the Garonne, and the Rhone, all of which important rivers had been largely benefited by the art of the engineer. The canal system of France was historic, one of the earliest of these artificial cuts being the celebrated canal of Languedoc, 171 miles long, and built by Riquet in 1667–81, and now forming part of the Canal du Midi. From its summit level, 600 ft. above the sea, it communicated with the Garonne, and therefore with the Atlantic, by twenty-six locks, while its southern slope descended by seventy-three locks to the Mediterranean. Statistics were given showing that, up to 1878, on 7,069 miles of waterways, France had spent upward of £43,000,000, or considerably more than double spent by the United Kingdom up to 1844. Nevertheless, it was intended still further to extend, improve, and systematize this means of communication, at an estimated further cost of £40,000,000.

Spain and Portugal possessed partly in common eight principal rivers, of which five, the Minho, Douro, Tagus, Guadiana, and Guadalquivir, drained the western valleys and flowed into the Atlantic, while the other three, the Ebro, Incar, and Segura, discharged into the Mediterranean. The characteristics of these rivers were described. As a rule they were only navigable for a limited portion of their course, and were chiefly remarkable for the exhibition of peculiar natural phenomena and of extremes of flood discharge, a velocity of sixteen knots an hour having been noted in the Douro under certain conditions of tide. The canals of the Iberian peninsula were unimportant; Spain possessed a length of 130 miles in 1875.

Italy was not rich in waterways except in the valley of the Po, the navigable portion of her rivers only attaining an aggregate length of 1,100 miles. Of these the Po, the Adige, and the Tiber were the chief, and their principal points were discussed by the lecturer. Although the total length of navigable canals in Italy was only 435 miles, the Italians were the first people of modern Europe that attempted to plan and execute such artificial waterways. As a rule, however, they had been principally undertaken for the purposes of irrigation. Of the Italian canals the most important were the Cavour Canal in Piedmont, the Grand Canal in Lombardy, and the canals of Pavia and Martesana. The provinces of Venice, of Padua, and the Emilia had all excellent canal systems.

Austria-Hungary possessed in the Danube the largest river in Europe, as regarded the volume of discharge, although it was inferior to the Volga in the length of its course and the area of its basin. This great stream first became navigable for flat-bottomed boats at Ulm, 130 miles from its source. In its total length of 1,750 miles it was fed by at least 300 tributaries, many of them large rivers, such as the Inn, the Drave, the Save, the Theiss, the Olta, the Sereth, and the Pruth. Indeed, the seven tributaries mentioned had a combined length of 2,900 miles, and drained one-half of the Danube basin. The navigation interests of this grand river system were of the highest importance, both from the commercial and the engineering points of view, and the lecturer dwelt at length on the works of improvement executed under different governments and administrations, dividing his remarks under three heads, namely, the Upper and Middle Danube, the Lower Danube, and the Mouths. After leaving Bavaria, the upper and middle section of the river passed through Austro-Hungarian territory, and had been the subject of continuous and unceasing effort in the direction of improving its capacity for navigation. Although the Danube between Vienna and Old Moldova had been regulated in numerous places and at great cost, there

had been but little appreciable improvement effected in its general navigable depth. On this account, projects having in view the permanent acquisition of a sufficiently wide channel of from 6 ft. to 8 ft. deep at every point between Passau and Basias had lately been prepared by Government engineers, which involved an outlay of £2,000,000, to effect the desired improvements. Traffic on the Upper and Lower Danube was mostly carried in about 800 barges belonging to the Danube Steam Navigation Company, of which the greater number gauged 250 tons. Much valuable information respecting the mode of traction on the Middle Danube had been procured from Mr. Murray Jackson, the engineer of the company in question, to whom, as well as to several other correspondents who had likewise kindly aided him in procuring information on other matters connected with his discourse, the lecturer tendered his acknowledgments.

The Lower Danube began at the foot of the Iron Gates, and terminated at the outfall in the Black Sea. The principal features of this section of the river were described, and it was stated that between the Iron Gates and Ibraila there was frequently a depth of 40 ft. at low water, but at seasons of very low water this depth was not more than 9 ft., and at the Nicopoli, Sistov, and Tchernavoda shoals it was reduced to 7 ft., 6 ft., and 4½ ft. respectively.

In conclusion, an account was given of the works undertaken by the International Commission, to which body the lecturer was appointed engineer in 1856, and had designed and carried out the works at the Sulina mouth, now on the eve of completion. The achievement of the programme of the Commission had resulted in there being everywhere a navigable depth of from 17 ft. to 20 ft. at the season of high water, and a minimum depth of 14 ft. at low water. In the Sulina branch, nine of its worst shoals had been successfully dealt with, and three cut-offs had been made, by which the river had been shortened two miles, and eight of its worst bends entirely suppressed. The total cost of these river-works, including maintenance and dredging, had not exceeded £300,000. At the Sulina mouth, where there was only a depth of from 8 ft. to 10 ft. before the construction of the piers, the depth for many years past, unaided by dredging, had not been less than 20½ ft. The cost of the piers, including their maintenance to the present time, had been about £220,000. The effect of these improvements had been to increase the trade from 680,000 tons gross in 1859 to 1,530,000 gross tons in 1883, and to lower the charges on shipping from an average of 20s. per ton of lighterage before the deepening of the Sulina mouth and the improvement of its branch to 2s. per register ton at the present time for commission dues. As a commentary on the hostile criticism evoked when the scheme was initiated, the lecturer drew attention to two facts, namely, that the works so unsparingly criticised in 1857 had already effected a saving of £20,000,000, and that experience had abundantly proved that the predictions of a rapid silting up to seaward of the Sulina piers had been completely erroneous.

MOTOR FOR SEWING MACHINES.

After woman's hand had been freed from the manipulation of the needle through the invention of the sewing machine, the idea soon occurred to substitute mechanical devices for the laborious work of the feet—a substitution which could only be a gain for hygiene.

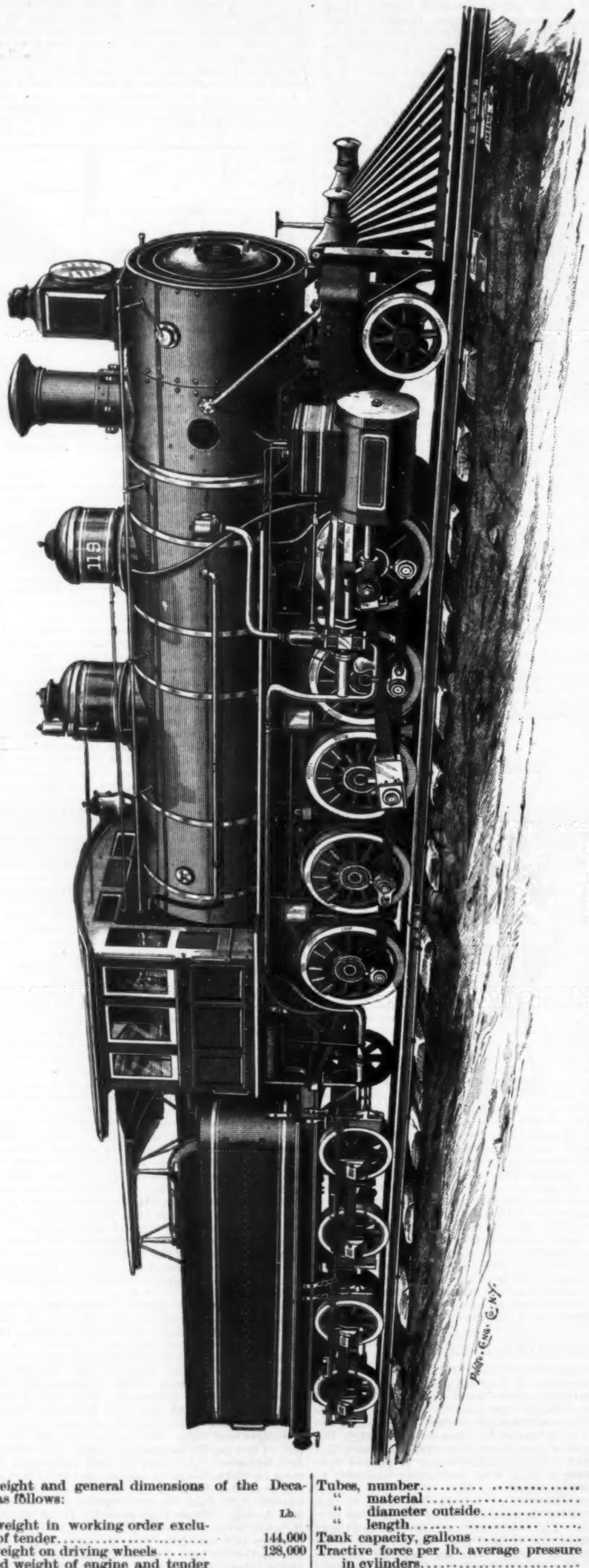
HEINRICI'S SEWING MACHINE MOTOR.

So there soon appeared in the market a large number of sewing machine motors that answered more or less to the requirements of the case. The most practical of these were water motors set in motion by water derived from an ordinary conduit. The only fault to be found with them was that they could not be established everywhere because of the preliminary installation that was requisite. In recent times motors for sewing machines have been shown at electrical exhibitions; but the trouble with these is that the time has not yet come when each house possesses the necessary electrical arrangements to run them. For practical purposes we need a motor that can be set up and operated everywhere, and we believe that a solution of the problem has been found by Mr. Louis Heinrici, of Zwickau. His motor, which is represented in the accompanying cut, is driven by steam produced in the cylinder above the machine.

The heat is furnished by a kerosene lamp, which at the same time illuminates the operater's field of work. The waste steam may be led out of doors by means of a rubber tube, or it may be condensed in a special apparatus that serves as a hot water reservoir. The power for small machines is $\frac{1}{10}$ horse. The motor may also be adapted to other apparatus used in the smaller industries.—*Science et Nature.*

THE LOCOMOTIVE DECAPOD.

The accompanying illustration represents a locomotive recently constructed at the Baldwin Locomotive Works in Philadelphia, for working a mountain grade on a Brazilian railroad. This engine shares with the Southern Pacific monster El Gobernador the proud title of the most powerful locomotive in the world.



THE LOCOMOTIVE DECAPOD, FROM THE BALDWIN LOCOMOTIVE WORKS.

The weight and general dimensions of the Decapod are as follows:

	Lb.
Actual weight in working order exclusive of tender	144,000
Actual weight on driving wheels	128,000
Estimated weight of engine and tender in working order	224,000

Cylinders	22 in. × 26 in.
Drivers, diameter on tread	45 in.
Total wheel base	24 ft. 6½ in.
Driving wheel base	16 ft. 11½ in.
Boiler, diameter	64 in.
" thickness of plates	⅝ in.
Firebox, inside length	121 in.
" " width	39½ in.
Tubes, number	268
" material	steel
" diameter outside	2 in.
" length	12 ft. 9½ in.
Tank capacity, gallons	3,500
Tractive force per lb. average pressure in cylinders	279·6 lb.

The boiler is probably the largest ever made for a

locomotive, and the same seems true of many of the other parts. The piston rod is 4 in. diameter, and the main crank-pins 6 in. diameter. The Laird cross-head is cast steel, and the slide-bars cast iron. The reverse gear is a combination of screw and lever, so arranged that either may be used.

It will be noticed that as the engine is to work in a hot climate, the fireman is protected from the sun by a roof over the front part of the tender.

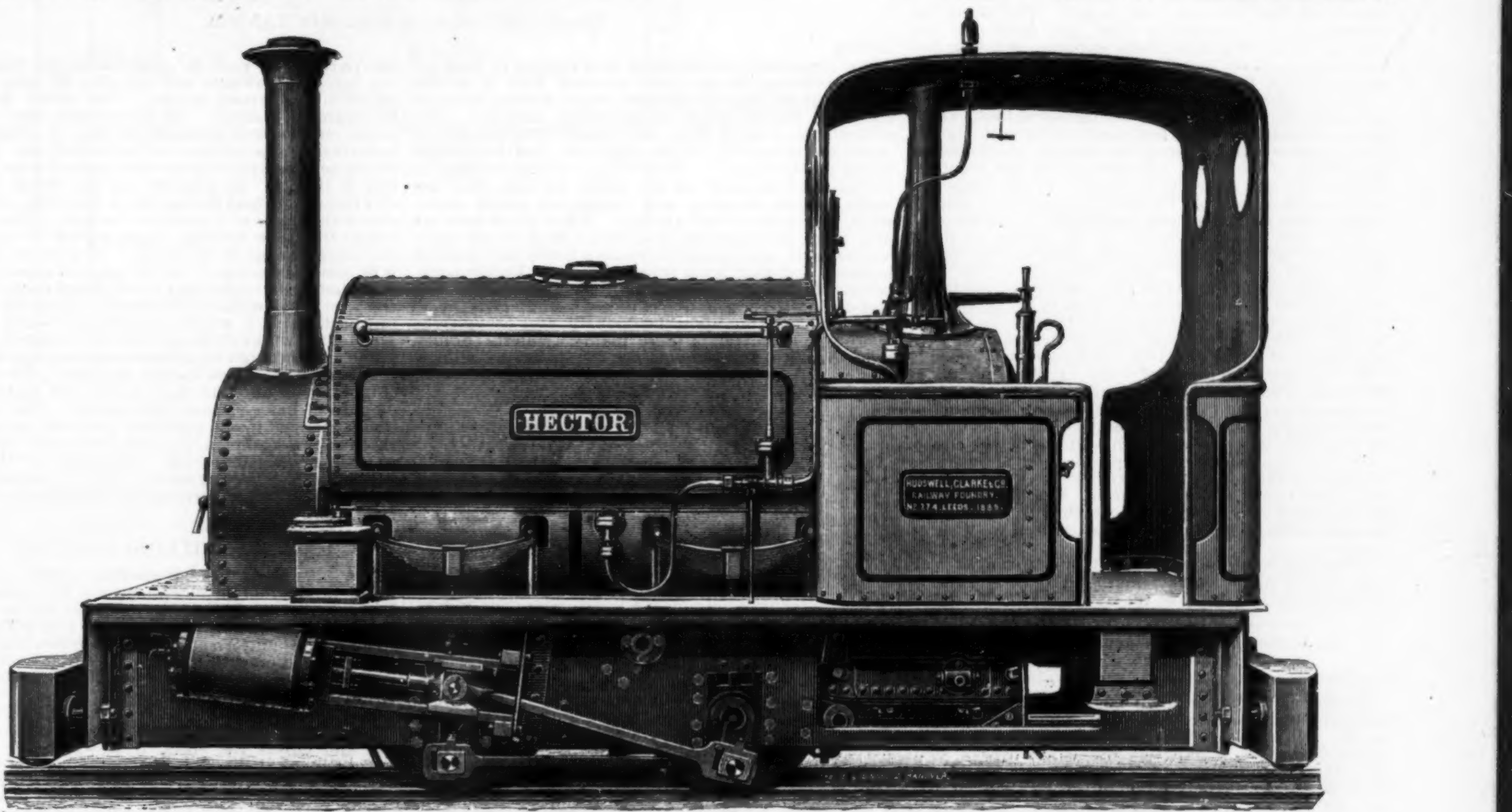
It is estimated that the engine will haul 500 gross tons, or 1,120,000 lb., of cars and lading up a straight grade of 105·6 ft. per mile.

TANK LOCOMOTIVE, 18-IN. GAUGE.

WE give a view of one of four neat little tank locomotives recently built by Messrs. Hudswell, Clarke & Co., of Leeds, for the 18-in. gauge railway at Woolwich Arsenal. The engine has outside frames and outside cylinders; the latter, which are 7 in. in diameter by 12 in. stroke, being connected by a strong casting bolted between their valve chests so as to insure a thoroughly firm fixing. The four wheels, which are coupled, are 2 ft. in diameter, and are of cast iron with steel tires. The axles are also of steel, with, of course, outside bearings only.

The boiler has a barrel 2 ft. 3 in. in diameter by 5 ft. 10½ in. long, and is provided with a copper fire-box and thirty-six brass tubes 2 in. in diameter. On the boiler is placed a saddle tank containing 200 gallons of water, while the coal-box on the footplate has a capacity of 5¼ cubic feet. The boiler is fed by one pump and one injector.

The general design of the engine is very neat, and the fittings are complete and well arranged. The weight of the engine is 6½ tons empty, and 8 tons in working order.—*Engineering.*



TANK LOCOMOTIVE (18-INCH GAUGE) AT WOOLWICH ARSENAL.

A PLAN FOR SEWERAGE.*

THE city of Providence, in emptying the sewerage of 36,421 people and a large amount of manufacturing waste into the Providence River and its tributaries, has pursued the usual course of cities in this country and elsewhere, with the usual result of the pollution of all the natural drainage channels adjacent to the city.

This state of affairs has led the City Council to authorize the City Engineer, Mr. Samuel M. Gray, and his assistant, Mr. Charles H. Swan, to proceed to Europe and to investigate the various plans in practical operation for the disposition and utilization of sewage, and other matters relating thereto, preliminary to preparing a plan for disposing of the sewage of the city in such a manner as to be least injurious to the public health. The outcome of this action is a report containing a general summary of the information collected abroad, as well as the specific application of the same to the particular case in hand.

There are two standpoints, from either of which so voluminous and miscellaneous a collection, becoming a part of a report to a City Council, can be justified. One is, where each part of the material presented is a link in a chain of argument by which a proposed plan is to be sustained against an unfriendly reception. Another is, where it is important to bring educational influences to bear upon a community in order to secure the adoption of correct sanitary measures. As a considerable part of the matter contained in this report—though of great value as engineering literature—has no direct bearing upon the problems to be solved by the city of Providence, it is to be supposed that it was included for the latter purpose.

Though the parts of the city provided with sewers are committed to the combined system of sewerage, by reason of that system having already been carried out in a very thorough manner, there are other portions where the plan is still undetermined, and hence Mr. Gray discusses at considerable length the relative merits of the separate and combined systems, and concludes that, mostly for the unsewered parts of the city, it will be well to continue the one now in use, except in special cases, when the separate system may be used to better advantage.

Not the least interesting part of the book—as being a part not to be had elsewhere—is the table on pages 136 and 137, Appendix C, giving results of the measurements of flow in the outfall sewers. From this it is seen that the average dry weather flow of different sewers varies from 13¾ to 304 gallons per head of population connected with the sewers. This indicates that a large amount of subsoil water in some cases finds entrance to the sewers, while in other cases there is probably a loss of sewage by leakage.

While all parts of the report are of great interest, the main interest will, in the present state of the sewage question in this country, attach to the investigations and conclusions relating to sewage disposal.

In the course of these investigations, Mr. Gray has examined a number of works where sewage is purified by irrigation and by land filtration, as well as several where chemical and mechanical precipitation is in use; and at great pains has collected and collated in Appendix B statistics relating to this branch of the subject.

Though manifesting entire fairness in his methods, it seems to us that Mr. Gray has fallen into some errors of interpretation, and displays a shyness when it comes to applying his facts and abstract deductions—which are generally right—specifically to the case of Providence.

To us the logic of his labors inevitably leads to conclusions relative to disposing of the sewage of Providence differing materially from the proposed plan.

As to the sanitary merits of the two processes, land purification and precipitation, we fully agree with Mr. Gray. Thus we do not controvert his conclusion that "sewage is more fully purified by irrigation than by precipitation," and are willing to accept the statement that (see page 111, App. A):

"Chemical precipitation, as at present conducted, fails to remove the whole of the dissolved impurities of sewage. Nevertheless, it is sufficiently purified by chemical precipitation to meet the requirements of many cases where a high degree of purity is not needed, and a removal of the solids and suspended matters is the main object sought."

Nor do we feel disposed to differ from him as to the economic merits of the two processes, so far as his general deductions go. Thus the following conclusion seems warranted by the facts (see p. 112, App. A):

"So far as we are informed, precipitation works are an annual expense to the municipalities using them for the purification of their sewage. This result is to be expected. The annual cost of chemicals used forms no inconsiderable item, while the income derived from the sale of sludge for agricultural purposes is uncertain and unreliable."

But we do differ widely from him as to the economic merits of precipitation and land purification, when applied to the city of Providence, because, as it seems to us, his recommendations run counter to the facts collected by himself, and to his own abstract deductions from these facts, as well as to the best engineering knowledge and practice of the day.

We can best make clear the cause of this difference by comparing the annual cost of sewage disposal by precipitation with the cost of land purification, and capitalizing the results.

If we omit interest on disposal works and the cost of pumping when such is resorted to, we find by analyzing Mr. Gray's statistics relative to irrigation, that with the exception of Birmingham there is a balance in favor of the works; and that when this exception is rightly interpreted, it is a strong argument in favor of irrigation as against precipitation. At Birmingham, the two processes being combined—the sewage being first subject to the process of precipitation, and the effluent afterward used in irrigation—we have an opportunity of comparing the deficit in the two operations under like conditions of management. For 1883, this was for precipitation (to the nearest pound) £13,086, and for the farm, £3,506.

The late report of the Royal Commission on the disposal of London sewage estimates the cost of treating it by precipitation at one shilling per inhabitant per annum, which is equivalent to about $5,600 per annum for each million of gallons of sewage per day. At Burnley the corporation pays an annual subsidy to a company working the Scott process, of $4,200 per annum for each million of gallons of sewage per day.

On the same basis, the corporation of Coventry—according to Mr. Gray, page 112, App. A—pays the Rivers Pollution Association $6,765 per annum. At Bradford chemicals alone cost $2,530 per annum per million of gallons per day.

The commission appointed to propose measures for remedying the pollution of the Seine in the vicinity of Paris estimated that chemicals alone would cost $2,550 per annum per million of gallons per day.

On page xiv., Mr. Gray states the cost of chemicals and labor on well managed precipitation works in England to be 24 to 36 cents per annum per inhabitant connected with the sewers, though he admits that double this would be but a safe basis to take for this country.

The average dry weather flow of sewage of eight of the nine places, given in the report, having precipitation works is 32 gallons per inhabitant, which, at a cost of 24 cents per inhabitant per annum—the lowest cost given by Mr. Gray—gives $7,500 per annum for each million of gallons of sewage daily.

We believe it a fair inference from these facts that in this country it would not be safe to estimate the cost of sewage precipitation at less than $8,000 per annum for each million of gallons of the dry weather sewage.

Mr. Gray estimates the present dry weather flow in Providence at 3,000,000 gallons from 36,421 people connected with the sewers, which is about 80 gallons per person. He also estimates the manufacturing waste that finds independent access to the river at 4,823,000 gallons per day.

When the city shall have grown to a population of 300,000—the amount Mr. Gray provides for—and a general sewerage system taking in the manufacturing waste shall have been completed, it is a low estimate that places the sewage of the city at 30,000,000 of gallons daily. At the rate of $8,000 per million gallons, the annual expense of treating this sewage would be $240,000, which, capitalized at 4 per cent., would give $6,000,000 as the capital equivalent of the cost of conducting the precipitation works.

Mr. Gray estimates the cost of carrying out the proposed plan at $3,699,504, though this sum only includes the cost of sufficient precipitation tanks and pumping machinery for the needs of the city at the time the works shall be put into operation—the estimate of the demand of the city at that time being made on a liberal basis—and not for the whole 300,000 of population. Though not so stated, it is reasonable to suppose that it is not intended to provide, in the first instance, more than half the capacity of tanks, machinery, etc., that will be needed for a population of 300,000; and as the sums allowed in the estimate for these items amount to $420,433, we will be more than generous in assuming that the proposed works when fully carried out for a population of 300,000 will have cost $4,000,000. This, added to the capitalized expenses of precipitation, gives $10,000,000 as an equivalent capitalized first cost of the works, not including the expense of pumping.

Let us compare this with the probable cost, if land purification were to be used instead of precipitation. On page xiv. of the report is the statement:

* A proposed plan for a sewerage system and for the disposal of the sewage of the city of Providence, by Samuel M. Gray, City Engineer.

"Experience indicates that the amount of land required for the disposal of sewage by irrigation is about one acre to one hundred inhabitants. The population provided for in the proposed system of intercepting sewers is 300,000. The amount of land necessary to properly dispose of the sewage of that population would be about 3,000 acres. It has been suggested to take the sewage to Seekonk Plains for irrigation. The great expense of conveying the sewage across the Seekonk River, and to the land, together with the fact that the available area is less than one thousand acres, forbids a consideration of this scheme. It has also been suggested that the sewage be taken to Warwick Plains, and there used for irrigation. From extensive surveys of this territory I am satisfied that there is not sufficient quantity of suitable land in that locality for the future needs of the city. The estimated cost for construction in accordance with this suggested scheme, including only sufficient quantity of land for present needs, is $1,146,000 more than for the plan of precipitation herein recommended. The annual cost of pumping the sewage to Warwick Plains would be double the cost of the pumping required in the plan recommended."

The above statement regarding the amount of land required for the purification of sewage is evidently based upon experience in broad irrigation, where no special means are taken to prepare the land, and where everything else is made subsidiary to the raising of crops.

One acre to one hundred people is the lowest average for any town given in App. B. At Dantzic there is but one acre to 250 people, and at Edinburgh but one acre to 400 people.

The report of the Royal Commission on London Sewage Disposal, heretofore referred to, considers it safe to take one acre for 1,000 people. This being the judgment of a commission that has spent over two years in an investigation of the subject, and that has had access to every detail of experiment and of practice in Europe, is entitled to great weight.

We are informed by the manager of the Pullman sewage farm, that on their carefully prepared land, where the underdrains are 12½ feet apart and about 3½ feet deep, 10 acres will dispose of the sewage of the whole population of the town, amounting last fall to about 8,500 people, and allow the growth of certain crops to a considerable extent. At Pullman the amount of sewage is more than 100 gallons per inhabitant.

If therefore the purification of the sewage be made the prime factor in its use on land—downward filtration being used instead of broad irrigation, the land thoroughly underdrained and leveled—we are certainly warranted in assuming that one acre to 500 people will be ample to dispose of the sewage of Providence, so that instead of 3,000 acres being absolutely required for a population of 300,000, an area of 600 acres will suffice.

Not knowing the price of land at Seekonk or at Warwick Plains, or the difficulties encountered in reaching them and in properly preparing the land, or their distance from the pumping works, it would be presumption in us to hazard an estimate of the cost of carrying out a scheme of land purification at either or at both of these places. Fortunately, however, Mr. Gray has, in the above quotation, supplied sufficient data to allow of a safe guess, which will be accurate enough for the purpose of the comparison we wish to institute.

According to his estimates, land purification at Warwick Plains, including sufficient land for present needs, would amount in first cost to:

Cost of plan recommended	$3,699,504.00
Additional cost of going to Warwick Plains	1,146,000.00
Total	$4,845,504.00

He does not say how much land is included in this estimate, but speaks of it as only enough for present needs. We suppose of course that he has based the amount upon the population when the works shall have been put into operation, at the rate of 100 persons to an acre. As the population of the city was, in 1880, over 100,000, it is not likely that he has taken less than 100,000 as being connected with the sewers, in which case the above estimate probably includes 1,000 acres of land. Assuming, however, that it only includes 600 acres, and that it does not include the cost of as thorough preparation as needed, but that it will cost $500 per acre additional to put it in the proper condition for downward filtration, we would have $4,845,504 plus $300,000—the cost of additional preparation of 600 acres at $500 per acre—or $5,145,504 as the total cost of carrying out land purification at Warwick Plains for a population of 300,000, as against a capitalized cost of $10,000,000 for precipitation works, giving a saving of $4,854,496 in favor of land purification.

This comparison of course is based upon the supposition that the land would rent for enough, to market gardeners, to pay for the additional cost of pumping the sewage to the land, instead of pumping it into precipitation tanks, and for caring for the sewage at the farm, a supposition we think entirely warranted by experience.

We have gone into Mr. Gray's estimates on sewage disposal more in detail than was at first intended, because, as we progressed in the examination of the report, we were more and more surprised to find the apparent ease with which facts could be misapplied, and the worse be made to appear the better reason.

As this is probably the first time in this country when precipitation has been formally recommended as a method of sewage disposal, and as it has been done in this case after so much painstaking investigation, and, as would appear superficially, is based upon such a mass of carefully arranged and valuable facts, we are of the opinion that its weak points, if any, should be understood.

Aside from the importance that no single city like Providence should be led into what we believe engineering science and experience teaches would be a gigantic mistake, it is tenfold more important that any leading steps that may be taken in a country that is so full of examples of recklessness in sewage disposal should be made on firm ground; and that what is likely to become a precedent for less able and less progressive minds than Mr. Gray's should have the best of foundations to stand upon.—*Amer. Engineer.*

Pittsburg proposes to use its natural gas to burn the city sewage and garbage, as the Jews did that of Jerusalem in the valley of the Gehenna.

THE MANUFACTURE OF WREATHS OF IMMORTELLES.

What singular and often important and prosperous industries spring up and grow without any one, scarcely, having a suspicion of their existence! Who of us has not piously deposited a wreath of golden-tinted immortelles upon the grave of a friend without knowing that the production of such an object affords a living to thousands of workmen, and at present borrows the most ingenious of its processes from mechanics?

An ingenious workman, Mr. Gellit, formerly a harness maker, has recently invented a very ingenious machine for the manufacture of these frames, which are called *paillons* (from *paille*, "straw"). This machine was presented before the Societe d'Encouragement at one of its last meetings, and is at present operating in some of the large shops at Montreuil-sous-Bois. The apparatus as a whole consists of a large wooden bench at the extremity of which is fixed the mechanism properly so called (Fig. 1). This mechanism consists essentially of a matrix wheel that separates into two parts. The part, R, carries a bobbin from which the iron wire unwinds, and the part, R', may be taken off when it is turned upward. The wheel is revolved by means of gearing. As it revolves, the workman passes straw into it (as shown in Fig. 1), which is thus converted into a cylinder of the desired size, that is at the same time wound with wire derived from the bobbin, R (Fig. 2). In measure as the straw makes its exit from the wheel it runs into a zinc form, where it assumes the shape of a crown or wreath. The wire envelops the straw spirally, being guided by grooves in the internal edge of the wheel. As soon as the frame is finished, the cover, C, of the wheel is raised with the right hand, the upper part of the wheel is removed, and the wire is cut with the left hand. Then the parts are put back in place, and the operation is begun again. In Mr. Gellit's works there are several benches placed in a line and actuated by a steam engine. Each apparatus produces 75 dozen frames per day. These frames (Fig. 3) are of different sizes, and so the matrix wheels employed have various dimensions. The latter are easily changed in the machine, and are placed within reach of the workman, in cases numbered from 1 to 15 according to the diameter. Alongside of these cases may be seen in the engraving vertical compartments in which zinc forms of corresponding numbers are kept.—*La Nature.*

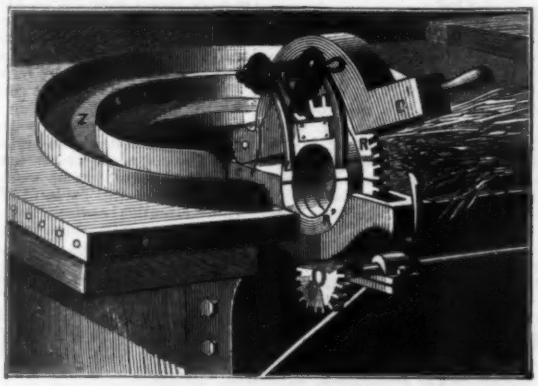


Fig. 2.—DETAILS OF THE MECHANISM.

The immortelle is cultivated over regions of vast extent. One may see the fields covered with it in the vicinity of the city of Ollioules, where several hundred thousand francs' worth are annually gathered. The collecting is done in May, the stems being severed at about ten inches below the corymbs, just before the flower-heads expand. This work is always confided to women. In measure as the stalks are cut, they are made up into bunches, and suspended heads downward, and dried in the open air. When the flowers are dry, they are made up into bunches of about eight ounces each, and packed in wooden boxes that hold 100 bunches, and that fetch from $11 to $12. Entire populations devote themselves to this culture in the Var, and during the season one may see young girls in all the villages sitting upon the door-sill, and occupied in making up packages of these plants. Valette, Sollies, Saint Nazaire, and Bandols are the principal villages in the vicinity of Ollioules where this industry is carried on. These regions, sheltered from the northerly winds by the high mountains which skirt the shore of Provence at a few miles distance, are particularly favorable for the culture of the immortelle.

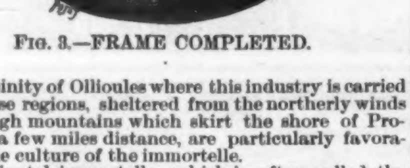


Fig. 3.—FRAME COMPLETED.

The Oriental immortelle, which is often called the "everlasting," and the "yellow immortelle," has been known in Europe since 1629. It is thought to be indigenous to the isle of Crete. It has been cultivated industrially, only since 1815. The culture of it is very remunerative, each clump of immortelles producing, on an average, from sixty to seventy branches, that bear from twenty to thirty flower heads. An acre containing, on an average, 20,000 clumps, produces each year from 1,200,000 to 1,400,000 branches that yield 7,700 pounds of immortelles. The boxes of immortelles are shipped to Marseilles, Bordeaux, Lyons, and Paris, where they are made into funeral wreaths, by mounting them by hand upon straw frames wrapped with wire.

A NEW MILLING MACHINE.

A well-known French machine-maker, accustomed to the production of machinery for the woolen trade, has patented a new milling machine, whose construction contains so many novelties, and is so different from the universal pattern of milling machines, that we deem it advisable herewith to place a description before our readers, together with a vertical section of the machine.

The cloth enters the machine through a peculiar feeding apparatus, K, then passes between two feed rollers, *l l'*, and enters the space, H, in which the bottom is formed by an inclined iron, copper, or wood undulated surface, E, and a similarly shaped hammer, A; it then passes between the two rollers, *l²* and *l³*, which act either as drawing or as brake rollers, falls to the bottom of the machine in the usual manner, and then returns again to the feeding apparatus. The hammer, A, hangs in coach springs, B, and slides in guides, D; it obtains its motion from the fly-wheel, C, and thus makes from 200 to 300 strokes per minute. The connecting rod of the hammer can be lengthened or shortened, according as the distance between the hammer and the plate, E,

Fig. 1.—MACHINE FOR MAKING FRAMES FOR WREATHS OF IMMORTELLES.

is wanted greater or smaller. In this manner the hammer effects vertical strokes, but sometimes a frictional heating is required, and for this purpose another motion is thrown into gear. The hammer is connected with an arm, F, at whose extremity a small pulley, o, is attached, which glides in a curved guide, G^1, attached to the frame, G, of the machine. According to the position of this guide, the hammer is thrown more to one side and lifted back again with each stroke, and thus obtains a rubbing action upon the cloth. The plate, E, has an inclination in order to facilitate the forwarding of the cloth. The speed of the feed roller, $l\,l^1$, can be regulated by cone pulleys. The rollers, $l^2\,l^3$, are driven by a strap and pulley on the lower one, which receives its motion from the roller, l, and then runs at the same speed as the latter; in that case the cloth passes over the plate stretched. When, however, the rollers, $l^2\,l^3$, are to act as brake rollers, and to gather the cloth in vertical folds on the plate, E, the strap is removed from the roller, l^3, and the roller, l^2, is then weighted; this retards the motion of the cloth, as shown in our illustration. The feeding arrangement, K, has an oscillating motion whose stroke can be varied, or which can be thrown out of gear altogether. Fig. 2 shows this feeding motion in section; the partitions, K^1, K^2, K^3, can be used separately for the passage of the cloth in the rope, or the divisions can be removed and the cloth passed through open. When a cloth is to be milled in the width, and only slightly in the length, the whole of it is passed through the middle partition, K^2; the feeding arrangement is then regulated in such a manner that it oscillates, and lays the cloth upon the plate, E, in a serpentine manner, while the stroke of the hammer is vertical. In this manner the warp ends are rubbed against each other, and the cloth mills less in the length than in the width. If the contrary is desired, the oscillating motion of the feeding arrangement is thrown out of gear. The cloth is passed through in three or six ropes, one or two of which pass through each of the three divisions, K^1, K^2, K^3, and pile vertically on the plate, E, the rollers, $l^2\,l^3$, acting as a brake to prevent its passing on too quickly. In this way the stroke of the hammer effects principally the weft, and the cloth mills lengthways. When the cloth is to be milled both in the length and the width, it is passed through two openings, K^1, K^3, which then receive an oscillating motion, and the speed of the hammer is reduced to one-half; the position of the cloth is then in oblique pleats. When only the width is to be milled, and nothing has to be lost in the length, the cloth is passed through three or six divisions, and the rollers, L^2, L^3, are geared so that they pull the cloth; it is thus stretched in the space, H, and the warp ends kept at their full length; the stroke of the hammer may then also be so regulated that it even stretches the warp.

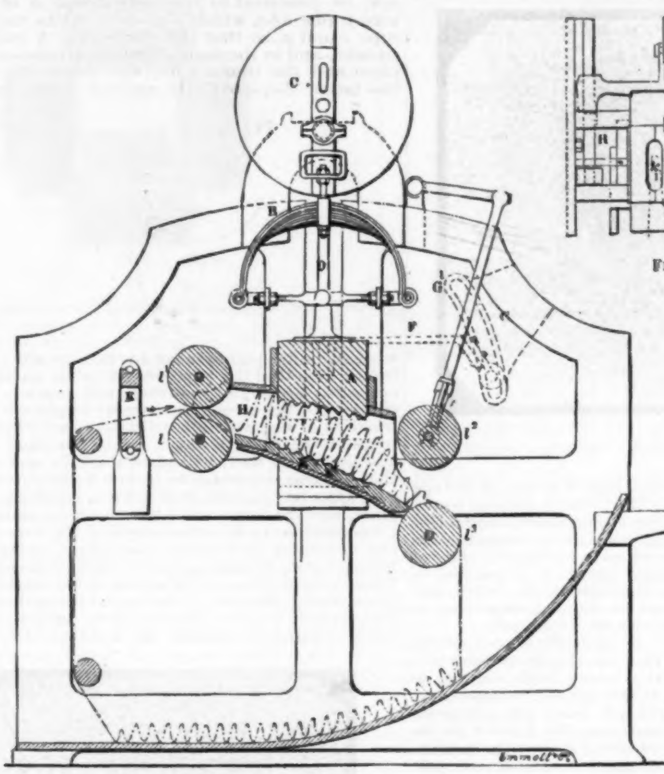


FIG. 1.

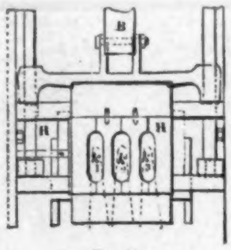


FIG. 2.

IMPROVED MILLING MACHINE.

THE CARBURETING OF ILLUMINATING GAS.

AN endeavor has often been made to increase the illuminating power of gas by means of carbureted vapors designed to enrich it with carbon, but no process has up to the present time given so good results as the one we shall here describe, and that consists in the use of *albo-carbon*. This product, which is prepared by Mr. Roosevelt, comes in the form small white candles. It is nothing else than highly refined naphthaline, the vapors of which, mixed with ordinary gas, give the latter considerable illuminating power.

As well known, naphthaline can be afforded at a low price by gas works, which produce large quantities of it.

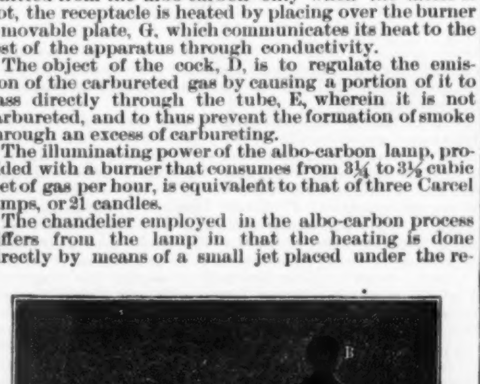
The apparatus designed to receive the purified product may be adapted to any of the existing gas-lighting systems. They are of various forms, but all are referable to two types, which we shall describe, and which start from the same principle, viz., the heating of the naphthaline in a receptacle by gas, and the mixture, in this same vessel, of the gas and vapor, so that they reach the burner in a state of absolute homogeneousness. The two forms of the apparatus are the lamp and the chandelier.

The former, which is shown in the accompanying engraving, consists of a receptacle, A, containing the albo-carbon. To the base of this is soldered a regulating cock, D, which is affixed to a conical coupling, C, screwed on the pipe in place of the ordinary burner, and giving passage to the gas. The albo-carbon is introduced through an aperture in the top of the receptacle closed by a screw cap, B. The gas enters through the cock, D, which is forked, and allows it to pass either into the tube, E or F, according as the cock is turned to the left or right. The tube, E, leads the gas directly to the burner, J. When the gas passes through the tube, F, it enters the receptacle through small apertures in the lower part of the tube, mixes with the vapors of the albo-carbon, and enters the tube, E, which leads it to the burner through the tube, I. As vapors are emitted from the albo-carbon only when the latter is hot, the receptacle is heated by placing over the burner a movable plate, G, which communicates its heat to the rest of the apparatus through conductivity.

The object of the cock, D, is to regulate the emission of the carbureted gas by causing a portion of it to pass directly through the tube, E, wherein it is not carbureted, and to thus prevent the formation of smoke through an excess of carbureting.

The illuminating power of the albo-carbon lamp, provided with a burner that consumes from 3¼ to 3½ cubic feet of gas per hour, is equivalent to that of three Carcel lamps, or 21 candles.

The chandelier employed in the albo-carbon process differs from the lamp in that the heating is done directly by means of a small jet placed under the receptacle, and the intensity of which is regulated automatically by means of a cut-off placed at the extremity of an iron rod contained in the copper tube that leads the gas. In measure as the apparatus becomes heated, the copper tube expands and abuts against the cut-off, and reduces the space through which the gas is passing.



ALBO-CARBON LAMP.

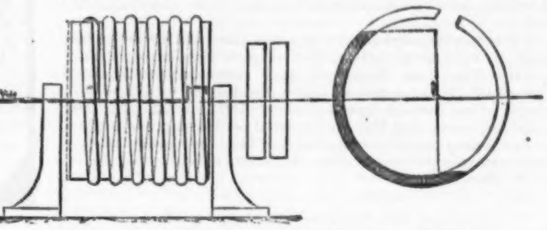
The receptacle contains no other internal tubes than the one designed to supply the gas jet. The gas mixes freely therein with albo-carbon vapors, the emission of which is regulated automatically, since it is in a ratio inverse to the heat developed by the jet. After this it flows into the tubes terminating in burners.—*La Nature.*

A NEW VACUUM APPARATUS.

MR. G. DESRAMEAUX has recently taken out a patent for a machine for producing a vacuum, the principle of which is very simple. It appears to have been used in the industries, and especially by manufacturers of incandescent lamps, and is said to quickly produce a nearly absolute vacuum. The apparatus consists of a horizontal wooden cylinder, a yard in diameter, movable upon an axis that rests upon two pillow blocks through the intermedium of two journals.

Around this tube runs spirally a copper, glass, or rubber tube, which is closed at each end by a cock, and contains mercury. When the cylinder is revolved, the mercury, by virtue of centrifugal force, moves forward in the spirals, and produces a vacuum behind it. Upon revolving the cylinder in the other direction, a vacuum is formed on the other side.

We have here, then, a sort of quick working rotary mercurial tromp. In the industrial models the play of the cocks or valves at the extremity of the tubes is automatic. The extremities of the spiral connect with the hollow axle, and this permits of the vacuum being utilized.—*Le Genie Civil.*



MACHINE FOR PRODUCING A VACUUM.

VARLEY'S FLEXIBLE CARBON ARC LAMP.

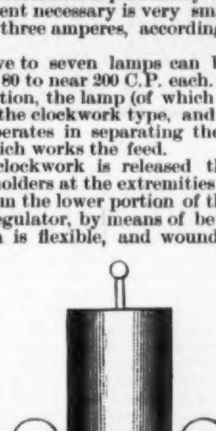
IT would appear that the several attempts to produce small arc lights have not been, as a rule, attended with such success that the results could be deemed satisfactory in a practical sense. Among other drawbacks, the difficulties of centralizing the carbon electrodes when of small diameter, with the attendant flaring and rotation of the arc round the points when out of truth, as well as the few hours the lamp would burn without attention, have prevented this type of lamp coming into extensive use.

In the lamps exhibited (the invention of Mr. Varley) the drawbacks before mentioned are said to be absent, and it is claimed that:

1. The centralizing of the carbons and constancy of the arc is secured by the carbons feeding in a horizontal manner (instead of vertically) a kaolin block in suspension over the space between the electrodes, and self-adjusting.
2. The number of hours the lamp is capable of running without attention is practically unlimited.
3. The current necessary is very small, ranging from about two to three amperes, according to brilliancy of arc.
4. About five to seven lamps can be run per H.P., varying from 80 to near 200 C.P. each.

In construction, the lamp (of which the sketch gives an idea) is of the clockwork type, and contains a main coil which operates in separating the carbons, and a shunt coil which works the feed.

When the clockwork is released the carbon is fed through the holders at the extremities of the two levers projecting from the lower portion of the bottom of the body of the regulator, by means of bevel wheels. The carbon, which is flexible, and wound on bobbins on each side of the lamp case, is pushed forward in the fashion of an ordinary lamp wick. The shunt coil, by drawing up the rod attached to the scissor-like arrangement, brings the lever ends together, releases the clockwork actuating the bevel wheels, thus pushing a fresh supply of electrode through the jaws. The resistance of the arc thereby diminishing, the main coil comes into action, reversing the action of the scissors, widening out the levers, and reforming the right length-arc of about $\frac{3}{8}$ of an inch. As the distance between the carbons increases, the flame widens and has a tendency to rise above the horizontal line in a proportion greater than the actual augmented width of arc. To counteract this difficulty, which is the parent of flickering and objectionable shadows, the kaolin block descends as the jaws widen, flattens the flame, spreading it out over the under surface, keeping the arc in its normal position, and in the best locality for emitting the luminous rays.



The lamps are constructed for alternating currents, and in burning are in appearance and color of light very similar to the Sun lamp.

The carbons consumed in this apparatus are of the well-known Varley flexible carbon cord, prepared in a special manner; they are consequently fibrous, and formed of numerous minute strands joined up in a

plaited manner. This arrangement makes a porous carbon of high resistance, although each separate strand is extremely dense and homogeneous. From this results the fact that they burn away entirely, not disintegrating in the customary way with pressed and moulded carbons, thus avoiding a considerable annoyance from the dust. The heated part of these cords is confined within narrow limits, and embraced within the flame, thereby aiding total consumption and dissipation of the elements. The resistance of this carbon per foot is about 10 ohms cold; this necessitates the contacts being very near the extremities and close to the arc, which is also of high resistance, approximating from 15 to 20 ohms.

The lamps can be run either in series or in parallel circuit; as an instance of parallel running, they have been worked in seven parallels with three in series.

Those exhibited were working with a current of 2·27 amperes, measured by a Siemens electro-dynamometer with a potential of, it was said, 37 to 40 volts; the candle-power was considerably over 100, and it had been measured with a larger current to produce 250 candles per lamp.

The light was good, with a slight but not disagreeable tint, and the steadiness was up to the usual standard.

A few mechanical improvements that are about to be made in various details of the construction should render this lamp an electrical and commercial success. For street lighting alone there should be a large demand, the carbon costing very little relatively to moulded ones, and the amounts of each lamp in candle-power being highly suitable for that purpose, while they can run for some days without attention.—*Electrical Review.*

[Continued from SUPPLEMENT No. 488, page 7792.]

THE HYDRODYNAMIC RESEARCHES OF PROFESSOR BJERKNES.

By CONRAD W. COOKE.

WE shall now refer to the three classes of phenomena in detail, and in the order in which we have classified them:

1. The effect of the vibrating cylinder upon the fluid in which it is immersed may be investigated by the apparatus which we figured and described in connection with Professor Bjerknes' earlier experiments,* and

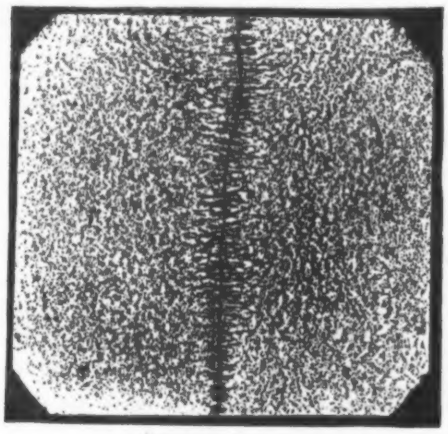


FIG. 6.

which consisted of a hollow metal cylinder with hemispherical ends supported upon a vertical fine elastic steel wire, rising from a firm stand, and surmounted by a camel's hair pencil, which, projecting out of the fluid in which the apparatus is immersed, can be made to record the direction and amplitude of the vibrations on the under side of a plate of glass or sheet of paper. When this apparatus is immersed in glycerine, and placed in different positions within the field of influence of a vibrating cylinder (such as that shown in Fig. 3), a diagram can be produced which is a graphic record of the directions and extent of the vibrations within that field of influence, but it will be found that in the case of glycerine the field of influence extends but a short distance from the vibrating cylinder, and that the motion communicated to the fluid by the vibrating cylinder, which at the surface of contact is very nearly equal to that of the cylinder itself, very rapidly falls off as the distance from the cylinder increases, and

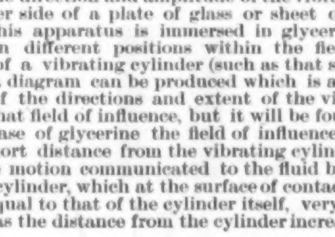


Fig 7.

that, moreover, the phase of vibration is more and more retarded until at a few millimeters distance from the cylinder the direction of movement is reversed; showing that the ratio of the coefficient of viscosity to the density of the fluid is not large enough to insure the most marked results.

By employing in the place of glycerine a fluid, such as maize sirup, of far greater viscosity, a diagram may be obtained, illustrating not only a largely extended field of force around the vertical vibrating cylinder, but the figure so produced is identical with that obtained by iron filings scattered over a glass plate and around a vertical wire, through which an electric current is passing (Fig. 1, see page 7791 *ante*). And in the same medium, by employing the horizontal vibrating cylinder shown in Fig. 5, in conjunction with the secondary apparatus, a figure is obtained which is identical with that produced by iron filings on a glass plate, below which, and parallel to its plane, is fixed a wire through which a current of electricity is being transmitted; see Fig. 6.

If two cylinders each circularly vibrating about their vertical axes, and of the form shown to the left of Fig. 3, be introduced into a viscous medium, such as maize sirup, and within the range of each other's field of vibration, figures may be produced with the recording apparatus which are identical with the filing figures produced upon a horizontal plate around two vertical wires conveying electric currents. If the two cylinders

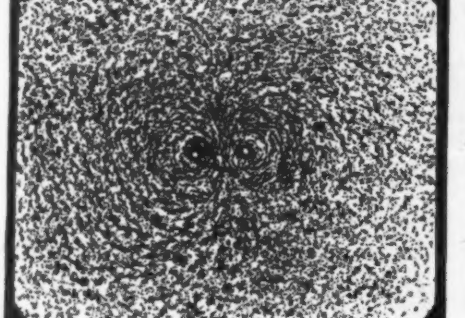
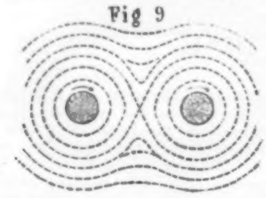


FIG. 8.

are moving in opposite phases, that is to say, if the one be rotating to the left while the other is moving to the right, the figure shown in Fig. 7 is produced; and if this figure be compared with Fig. 8, which is a reproduction of the filing figure produced on a horizontal plate of glass around two wires whose direction is parallel to the plane of the plate, and through which electric currents are being transmitted in opposite directions, it will be seen that the two figures are identical.

If now the two cylinders be similarly placed within the viscous medium, and they be circularly vibrated, but in the same phases, that is to say, both moving to the right or both moving to the left at the same time, then the recording apparatus will trace out a diagram similar to Fig. 9, and on comparing this figure with the filing figure, shown in Fig. 10, it will be seen to be identical in form with the arrangement of magnetic par-

Fig 9



ticles around a field of force produced by two parallel electric currents, moving in similar directions, but perpendicular to the plane on which the magnetic particles are scattered.

One of the most interesting of this series of Professor Bjerknes' experiments is the reproduction in a viscous medium of a field of vibration represented by a diagram which is identical with that obtained by iron filings around a magnet through which an electric current is being transmitted. Professor Bjerknes, reasoning that while a body pulsating within a viscous medium sets up in that medium *radial* lines of force, and a circularly vibrating body produces a field of *concentric* circles of force, combined the two and produced the diagram, Fig. 11, in which a spiral figure is drawn which is a sort of compromise between the radial lines of force and the concentric circles produced by a circularly vibrating body. Fig. 12 is the figure produced around the pole of a magnet through which an electric current is being transmitted, by iron filings scattered on a plate, the plane of which is perpendicular to the axis of the mag-

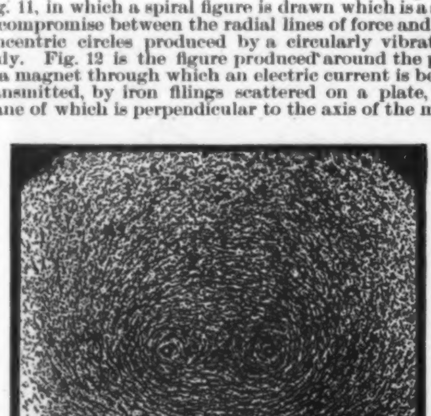
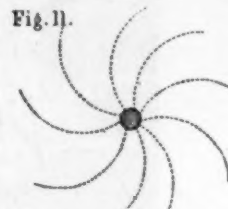


FIG. 10.

net, and to the direction of the electric current, and it will be seen that the figure drawn by Professor Bjerknes' apparatus is identical in form with it; thus giving another striking example of the very close analogy which exists between the effect of vibrating bodies in a viscous medium and magnetic and electric phenomena.

2. We will now consider the mutual effect produced by bodies circularly vibrating in the same viscous medium, and it will be seen that this class of phenomena bears a remarkably close analogy to the effects produced by electric currents transmitted through conductors, of which one or more are capable of moving under the influence of whatever dynamical forces may be called into action. These phenomena were investigated by Ampere in a research which has long become classical, and it will, in this place, be necessary only to refer to one figure connected with that research as explanatory of Professor Bjerknes' hydro-dynamic analogue of the mutual action of electric currents upon one another. If a wire, A (Fig. 13), through which an electric current is being transmitted in the direction of the arrow, be presented to the vertical side, *a*, of the light wire frame *a b c*, which is pivoted in the two mercury cups, *x* and *y*, so that the current in A and in *a* are parallel, and in the same direction, attraction will take place, and the frame, *a b c*, will follow the wire, A, if the latter displaced. If, on the other hand, the

Fig. 11.



wire, A, be be placed near to the opposite side of the frame, *c*, so that the two currents while parallel are in opposite directions, repulsion will ensue. If now a wire conveying an electric current be placed below the frame as at B, attraction will take place when the currents in the wires, B and *b*, are in the same direction, and the frame, *a b c*, will place itself in such a position that *b* becomes parallel to B; but if the currents in the two wires be opposite in direction, repulsion will take place, and the frame will rotate until its plane becomes perpendicular to B. Once more, if the wire conveying the current be presented to one side, *c*, of the movable frame, but in a plane perpendicular to the plane of the frame as at *d*, then a deflection of the frame will take place, and if the wire, *d*, be moved lower down, the deflection will become less and less, until a point, *d′*, is reached which is opposite the middle of the length of

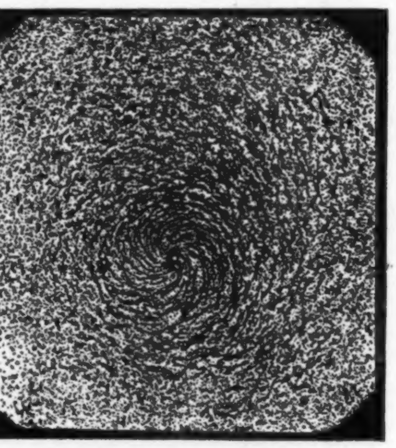


FIG. 12.

C; at this neutral point no deflection will take place, and if the wire be still further lowered, it will deflect the frame in the opposite direction, and this deflection will increase as the wire is lowered, until it reaches the point, *d″*, where the deflection will have reached its maximum, being equal to what it was when the wire was at *d*, and in an opposite direction.

All the above phenomena Professor Bjerknes has been able to reproduce hydrodynamically with remarkable accuracy, by means of the very beautiful apparatus shown in Fig. 5 (see page 7791 *ante*), and illustrated in the diagram, Fig. 13, so far as its essential parts are concerned. This apparatus consists of a light frame delicately poised between vertical axes on a rigid stand, F F, and carrying four cylinders, A, B, C, and D,

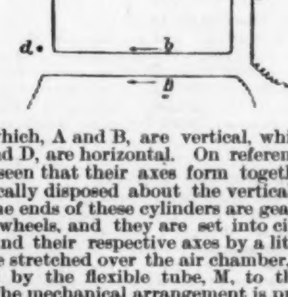


Fig. 13.

two of which, A and B, are vertical, while the other pair, C and D, are horizontal. On reference to Fig. 5 it will be seen that their axes form together a square, symmetrically disposed about the vertical axis of the frame. The ends of these cylinders are geared together by bevel wheels, and they are set into circular vibrations around their respective axes by a little vibrating membrane stretched over the air chamber, E, which is connected by the flexible tube, M, to the pulsating pump. The mechanical arrangement is precisely similar to that illustrated in Fig. 4 (page 7791 *ante*), there being a small connecting-rod attached to the center of the membrane in E, and taking hold of a crank-pin inside the slot shown in the cylinder C (Fig. 5). When all these cylinders are set into oscillation, they repre-

* See *Engineering*, vol. xxxiii., page 192.

sent a closed electrical circuit such as that illustrated in Fig. 13, and the eight arrows around the figure (Fig. 14) indicate the direction of that current.

If now the vertical oscillating cylinder (shown at A, Fig. 3, page 7791) be placed close and parallel to the vertical cylinder, A or B (Figs. 5 and 14), repulsion will take place when the two cylinders are rotating in the same phase, that is to say, when they are both moving to the right or to the left at the same time; but when the cylinders are oscillating in opposite phases, at-

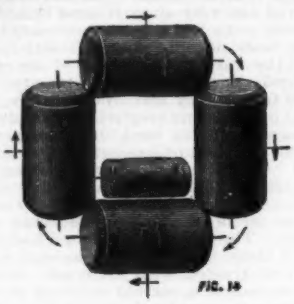


FIG. 14

traction will take place. These phenomena are illustrated in Fig. 15, the upper part of the figure marked R illustrating the repulsion between two cylinders vibrating in similar phases, and the lower part of the figure marked A shows the attraction effect of two cylinders vibrating in the opposite phases. The curved arrows indicate the direction of rotation at any given moment, and the straight arrows show the direction in which the cylinders tend to move through the medium. It will be observed that these phenomena are closely analogous to the action of electric currents upon one another, as illustrated in the diagram, Fig 13, although the phenomena of attraction and repulsion are inversed.

If now we take the horizontal vibrating cylinder, G, Fig. 5, and place it close to the lower horizontal cylinder, D, as is shown in Fig. 5, and again in the diagram, Fig. 14, the whole system of vibrating cylinders, A, B C, and D, will turn until the axis of the cylinder, D, lies in the same plane as that of the cylinder, G, and is moving in the opposite phase; and this will be its position of stable equilibrium; but if the frame carrying the cylinders be turned through an angle of 180 deg., the two cylinders will again become parallel; this time, however, their phases of oscillation will be similar, and the apparatus will be in its position of unstable equilibrium, as may be shown by moving it slightly to the right or the left, when it will immediately turn until the cylinders again become parallel and are vibrating

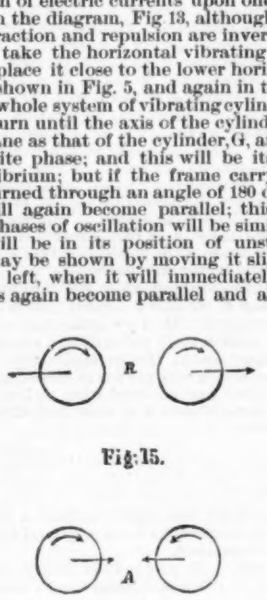


Fig. 15.

in opposite phases. In the position shown in the diagram, Fig. 14, the balance is in stable equilibrium when the cylinders are oscillating in the phase indicated by the arrows, D and *y*, and is in unstable equilibrium when oscillating in the phases indicated by the arrows, D and *x*. If the cylinder, G, be placed above D in such a position that its axis lies in a plane perpendicular to that of the axis of D (as is shown in Fig. 16), that is to say, in that position which is farthest from that in which the two axes of the cylinders lie in the same plane, then, if the two cylinders are oscillating in the phases shown by the arrows G, and D (Fig. 16), the axis of G will turn in the direction shown by the arrow, *x*, until parallelism between the cylinders is reached; and this corresponds very exactly with Ampere's experiment with two electric currents similarly disposed.

In the last mentioned series of experiments, Professor Bjerknes has produced the hydrodynamic analogues of attraction, repulsion, and rotation, by which what is called "action at a distance" is ordinarily made manifest in electro-dynamics, and in all cases has he demonstrated this by the use of circularly vibrating cylinders. He has, however, gone a step farther, for he has been able to reproduce phenomena analogous to the action of other electric currents upon one another, such as we have already described in connection with Fig. 13; as, for example, the effect upon the cur-


Fig. 16.

rent in the upright wire, C (Fig. 13), of a current passing through a wire whose plane is perpendicular to that of C, when in the positions indicated in the positions *d* and *d'* as well as in positions intermediate between them. Fig. 17 shows the arrangement of the apparatus for producing the analogues of these phenomena. A, B, C, and D are the four cylinders shown in Fig. 5, and which together are free to turn around a vertical axis; G is the horizontally vibrating cylinder, and if it be placed near to but at the upper end of A, the whole being submerged in viscous fluid, the latter will swing round either forward or backward according to the mutual phases of A and G; if the phases are those indicated by the arrows in the figure, then A will move forward in a direction perpendicular to the plane of the paper; on lowering the position of G this deflective action will become smaller and smaller until it reaches a point, G, opposite the middle of the length of A, where it will disappear altogether; and on still further lowering the cylinder, G, the deflective action, becomes stronger and stronger, but this time in the opposite direction, until the point, G, is reached, at which it again reached a maximum; and on comparing these hydro-

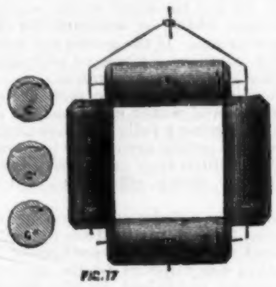


FIG. 17

dynamical phenomena with the electrical phenomena described in connection with Fig. 13, it will be seen that that they are inverse to one another.—*Engineering.*

ON THE PRODUCTION OF ALTERNATING CURRENTS BY MEANS OF A DIRECT CURRENT DYNAMO-ELECTRIC MACHINE.

By JOHN TROWBRIDGE and HAMMOND VINTON HAYES.

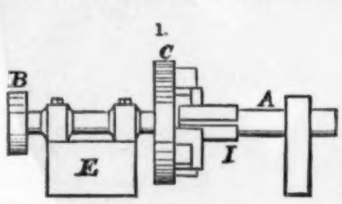
IT is often desirable to transform a direct current into an alternating one for the purpose of obtaining electricity of high tension by means of a Ruhmkorff coil, for studying the effects of stratifications in vacuum tubes, or for employing alternating currents in the study of magnetism. The best way is undoubtedly to employ an alternating dynamo-electric machine, as has been done by Spottiswoode. When, however, only a direct current machine is available, the following method can be employed:

The dynamo machine, if it is not a shunt wound machine, is shunted by a suitable resistance. We have employed for this purpose thin ribbon steel about 1·5 cm. broad and 0·01 mm. in thickness. The remaining portion of the current from the machine is conducted to two brass or copper segments, *a*, *a'*, Fig. 2. This current is led to the primary coil for, for instance of a Ruhmkorff coil from two other segments, *b*, *b'*. These segments are fixed upon a cylindrical shaft, A, Fig. 1, which is stationary. A belt passing over the pulley, B, turns the wheel, C, upon the face, D, of which revolve four brushes which connect the adjoining segments. The brushes, *a a*, *b b*, are made adjustable, the two adjoining brushes being electrically connected, and a small stream of water plays upon the segments of the commutator. The character of the spark produced by a Ruhmkorff coil which is marked by alternating currents has been studied by Spottiswoode. Without condensers in the secondary circuit a bright yellow glow spans the distance between the two terminals of the coil, which partakes more of the character of a voltaic arc than of the ordinary discharge from a Ruhmkorff coil. The apparatus we used produced three thousand reversals a minute. This rate was too rapid for the best effects with a Ruhmkorff coil. It enabled us, however, to study the musical note produced in the cores of the electro-magnet by rapid reversals of the current in the electro-magnet, and also the heating effects which have been so often studied.

Jefferson Physical Laboratory.

—*Amer. Jour. Science.*

1.



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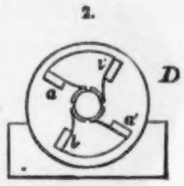


SOME PROPERTIES OF THE ETHER.

AT a recent meeting of the Royal Society, a model was presented, illustrating some properties of the ether, by Prof. G. F. FitzGerald, M.A., F.R.S. The model consisted of a series of wheels arranged at equal distances along parallel rows on axes fixed perpendicularly into a board. The wheels were connected together by India rubber bands, each wheel being so connected with its four neighbors. Under these circumstances it was shown that if any wheel was turned all the wheels turned simultaneously, and that, except for friction on the axes, etc., they would all turn equally. It was explained that the model only exhibited properties of the ether itself, and did not exhibit the connections of matter with ether. A region within which the bands did not slip represented a non-conducting region, and differences of elasticity of the bands represented differences of specific inductive capacity: slipping of the bands represented a conducting region, and complete absence of bands represented a perfectly conducting region. When bands were removed from a certain region and all around it a line of bands left, and all around outside this again a conducting region, then if a conducting line connected these regions, the wheels along this line might be turned in opposite directions, and when this is done all the non-conducting region is thrown into a state of stress by all the wheels not rotating equal amounts, in which the bands are tight on one side of a pair of wheels and loose on the opposite side. It was explained that this exhibited the polarization of the medium between two oppositely charged conductors, the direction of polarization being at right angles to these bands—*i. e.*, in the line joining the conductors—the medium in this state representing a charged Leyden jar, the two opposite electrifications being represented by the tight and loose bands, one conductor being bounded entirely by tight bands and the other by loose ones, and the electric displacement of Maxwell being represented by the difference between the two sides of a band. If the bands along any line between the two conductors slipped, all the energy of the medium was spent along this line in friction, and this is represented a discharge along the line. This energy was conveyed into the line of discharge by its side and not along its length in accordance with what Prof. Poynting has recently shown to be the case in all electric currents. If the resistance along the line of discharge were sufficiently small, the momentum of the wheels would carry them beyond their position of equilibrium, and the well-known phenomenon of an alternating discharge would be represented. This led to the observation that the magnetic displacement was represented by the angular velocity of rotation of the wheels and the self-induction by their momentum. It was remarked that the mechanical attraction between the two conductors was not represented, but it was explained that as this depends on the connection of matter with ether, it would require more complicated mechanism. It was, however, pointed out that by supposing the wheels slightly distorted by the stress, and by supposing a thread wound around them, and each end connected with the material of a conductor, a force would be produced drawing the conductors together, owing to the circumference of a distorted wheel being longer than of an undistorted one. This force would be proportional to the square of the distortion, a necessary condition not satisfied by ordinary stresses, and would be, if exerted between two infinite planes, independent of their distance apart, and so must represent a force varying inversely as the square of the distance. Returning to the electric currents, it was shown that by turning the wheels at any point of a conducting circuit the whole region was filled with turning wheels—*i. e.*, with magnetic displacement—and that, if a resistance were introduced at any point of the circuit, the energy would be transferred to that point through the medium, and enter by the side of the conductor. If two independent conducting circuits existed near one another, it was shown that the phenomena of induced currents were represented. It was explained that the mechanical force was not represented, as it depended upon the connection between matter and ether, but that it might be looked for as in some way depending on the centrifugal force arising from the rotations. The equations representing the energy of the model are of the same form as those of Maxwell representing the energy of the ether when limited by the consideration that the model was only in one plane. It was explained that a tridimensional model whose energy could be represented by the same equations as Maxwell's could not be constructed with India rubber bands, but might be constructed by means of wheels pumping fluid through pipes. This led to the observation that the propagation of waves by transverse vibrations could be illustrated by the model, and it was explained how a sudden turning of any set of wheels would start a wave-propagation whose direction of propagation was at right angles to the directions of magnetic displacement and of electric displacement, the former represented by the axes of rotation and the latter by the line joining the centers of a tight and loose band. It would be possible theoretically to construct a model illustrating the laws of reflection and refraction of light even at the surfaces of crystalline media, and to reproduce conical refraction. It was explained by twisting the medium the rotatory polarization of quartz might be represented, and that probably a mechanism might be introduced by which the rotation of other wheels or of something besides the wheels being altered by the rotation of the wheels, a reaction of the former on the latter would reproduce magnetic rotatory polarization. It was pointed out that both magnetic rotatory polarization and dispersion were due to a reaction of the medium during the wave-propagation, and not to a change of the medium independent of the wave-propagation. It was explained that it was not to be supposed that the ether was constructed of wheels and India rubber bands, nor even of wheels pumping fluid in pipes, but it was pointed out that some properties of the ether might be gathered from the model if it be assumed that the qualities of the ether represented by symbols obeying the laws of rotation for instance are really of the nature of rotation. If this be so, the ether must be such that any part of it can rotate as often as it likes, provided all the neighboring parts rotate equally, and the electrostatic stresses in the ether must be due to the difference of rotation of its parts. If the ether be a perfect liquid, it can only have such properties as represent rigidity by being in motion, and it was explained that many electrical phenomena might be illustrated by the polarization of the vortical motions in a vortex-sponge. Sir Wm. Thomson has pointed out that such a state of polarization as a single vortex region in the center of a cylindrical box will not of itself change unless it can spend its energy on the box, which is quite analogous to the fact that the energy of the polarization of the ether does not disappear unless it can produce heat or mechanical or other forms of energy. It was also pointed out that forces depending on small vortices vanished at small distances from them, and that hence forces depending on their polarization between two infinite planes would depend on the polarization and not on the distance between the planes, and so must be of the nature of forces varying inversely as the square of the distance. It was explained that the modes of polarization of vortices were sufficient to explain both electrical, magnetic, cohesional, and chemical forces. It was finally reiterated that the only possible way of giving anything of the nature of rigidity to a perfect liquid was by confer-

ring motion on it, and that it seemed likely that any mechanical properties could be conveyed by suitably chosen motions. This was quite in accordance with Sir Wm. Thomson's suggestive address to Section A at Montreal.

THE HON. SIR WILLIAM R. GROVE, D.C.L., F.R.S.

WILLIAM ROBERT GROVE was born at Swansea in 1811. His father was a justice of the peace and Deputy Lieutenant for the county. He received his early education at Swansea Grammar-school, whence he passed to Darlington House, Bath, and afterward to Brazenose College, Oxford. It was originally intended by his parents that he should enter the Church; but for conscientious reasons he preferred to adopt the legal profession, and was called to the bar in 1823.

During an interval of forced leisure, occasioned by ill health, Mr. Grove was led to return to the favorite study of his youth—electricity. Original research was soon followed by important discoveries. In 1839 he communicated to the Academie des Sciences, through M. Becquerel, the first idea of the gas battery (afterward produced by him in 1841), viz., the fact that "if a positive electrode be immersed half in water and half in a tube of hydrogen, and a negative electrode in water and oxygen, the water ascends in the tubes, the galvanometer is deflected, and the water is decomposed and recomposed by galvanic action." Later on in the same year Mr. Grove discovered the nitric acid battery which bears his name, announcing it to the world in a communication to the Academie. In 1840 he was elected a member of the Royal Society. In the following year he laid before the Electrical Society a new and ingenious process for engraving daguerreotype pictures by means of electricity. From 1840 to 1847 Mr. Grove was Professor of Experimental Philosophy at the London Institution, and it was in a lecture delivered there in 1842, "On the Progress of Physical Science since the Opening of the London Institution," that he briefly and clearly communicated the theory of the "Correlation of Physical Forces." This lecture was afterward further enlarged and published in 1846, since which time it has passed through several editions. The position taken up, to quote Mr. Grove's own words, was "That the various affections of matter which constitute the main objects of experimental physics, viz., heat, light, electricity, magnetism, chemical affinity, and motion, are all correlative, or have a reciprocal dependence. That neither, taken abstractedly, can be said to be the essential or proximate cause of the others, but that either may, as a force, produce the others; thus heat may mediately produce electricity, electricity may produce heat; and so of the rest, each merging itself as the force it produces becomes developed; and that the same must hold good of other forces, it being an irresistible inference that a force cannot originate otherwise than by generation from some antecedent force or forces." In spite of a steadily increasing professional work, Mr. Grove still continued to apply himself to scientific research. In 1847 he received the medal of the Royal Society, for his Bakerian lecture on "Voltaic Ignition, and on the Decomposition of Water into its Constituent Gases by Heat." Passing over several papers on the gas pile, etc., he spent some time in examination of "the electro-chemical polarity of the gases," "the electricity of flame," and the construction of a flame pile. He also conducted several experiments in search of the conversion of electricity into motion. In 1866 he was President at the meeting of the British Association at Nottingham, when he delivered an address on the "Continuity of Natural Phenomena."

In the midst of all this activity in study and research, which entitle Sir William Grove to so high a position among "Leaders of Science," it is hardly credible that he should have yet been able to reach as high an eminence in his own profession. He became a Q.C. in 1853, has been a member of several Royal Commissions, was knighted in 1871 on his elevation to the judicial bench, as Justice of the Common Pleas, and, by the operation of the Judicature Act in 1875, was appointed a Judge in the High Court of Justice.—*Science Monthly.*

SIR WILLIAM R. GROVE.

PURIFICATION OF DRINKING WATER BY ALUM.*

By Profs. PETER T. AUSTEN, Ph.D., F.C.S., and FRANCIS A. WILBER, M.S.

THE many discoveries that have been made during the last few years in regard to the transmission of diseases by drinking-waters have caused attention to be directed to the methods of its examination and the processes for purifying it. Chemical analysis can establish the presence of albuminoid matter in water, and by its means we are able to state if the water under examination can become a suitable nidus, or medium, for the development of disease germs. If the germs are actually there, or if the water contains a virus, or ptomaine,† biological examination alone can determine.

While physicians and scientific men are experimenting on the methods of water examination, and are endeavoring to understand fully the meaning of the results obtained, the public are chiefly interested to have some method by which they can purify their drinking water in a simple, cheap, efficacious, and expeditious manner.

Running over the substances which have been suggested and tried for the purification of water, there is none that seems to offer the advantages of alum. Particular attention was directed to its use by Jeunet in 1865, in an article published in the *Moniteur Scientifique* (page 1,007). He found that 0·4 gramme of alum to a liter of water (23·3 grains to one gallon) rendered it drinkable, even when it was quite full of foreign matter. The time taken for this clarification was from seven to seventeen minutes.

Alum is a double sulphate of potash and aluminum, and in this case breaks into potassium sulphate, which remains in solution, and a basic aluminic sulphate. This basic sulphate of aluminum, the composition of which is undetermined, precipitates as a more or less gelatinous and flocculent mass, and carries down with it the foreign matters and humus bodies. The sulphuric acid set free in the formation of the basic aluminic sulphate attacks the earthy and alkaline carbonates which are always present, and forms with them sulphates, setting carbonic acid free. Aluminic sulphate acts like alum. Aluminic acetate and ferric acetate do not give such good results. Peligot, however, found that ferric chloride (sesquichloride of iron) acted well, and Scherer recommends the use of a neutral sulphate of iron.

In the last years an extensive use of alum has been made in the many processes of purifying water, sewage, etc. It is not improbable that aside from its effect in precipitating matter mechanically by envelopment with the precipitating basic aluminic sulphate, the alum exerts a distinct coagulative action on the albuminous substances in the water, rendering them insoluble, and thus causing their precipitation; perhaps the same or similar effect that alum produces in the tanning of leather. One of the most prominent applications of alum at present is in the Hyatt filter. By the addition of a minute amount of alum, water is rendered capable of a most perfect mechanical filtration.

The fact that alum is cheap, and can be obtained in quite a pure state at any drug store, places it within the reach of every one. Its sharp taste precludes the possibility of its being swallowed by mistake. But even should it be swallowed by mistake, no great harm would be likely to ensue, unless a large amount were taken. In medical treatment as high as 30 grains are given in a single dose, and this may be repeated four times per day. If it can be proved that alum not only clarifies a water, but also removes from it disease germs and ptomaines, its use will prove of incalculable value to the human race, for facts begin to indicate that a vast number of diseases are communicated through drinking-water.

The investigation of the effects of alum on drinking water falls under the several heads—

I. Clarification of the water by settling.
II. Clarification of the water by filtration.
III. Use of water clarified by alum in manufacturing.
IV. Removal of disease germs.
V. Removal of ptomaines.
VI. Removal of organic matter.

The investigation must needs be both chemical and biological. Only the first and part of the second cases have so far been examined.

I. THE EFFECT OF ALUM IN CLARIFYING WATER BY SETTLING.

It is evident that to obtain practical results in the clarification of water by alum, it must be added in such small amounts as to leave no unnecessary excess, and that neither taste nor physiological action should be imparted to the water. At the time of our experiments (January, 1885) the New Brunswick city water was quite turbid from clayey and other matters, so that we were able to obtain some very reliable results.

The amount of alum used in the experiments of Jeunet seems to be unnecessarily high, in case the water is to be drunk. Water was treated with the amount of alum recommended by Jeunet (23·3 grains to the gallon), but no perfect settling was obtained under six hours or more; in some cases not under twelve hours. The water thus treated had no perceptible taste of alum, but it gave a decided reaction for alumina when treated with ammonia, showing that the water contained a certain amount of free alum. While the amount is evidently too small to produce any physiological effect, there seems to be no necessity to use such an excess.

To determine the effect of alum as a precipitating agent, tall cylinders were filled with water and a solution of alum was added, the whole well mixed, and allowed to stand. It was found that in varying lengths of time, depending on the amount of alum used, a gelatinous precipitate settled out, and the water above it became perfectly clear. On adding a relatively large amount of alum, and mixing, the coagulation and separation of the precipitate is at once visible, the water appearing by careful examination to be filled with gelatinous particles. The amount of alum necessary for the precipitation of a water will, of course, depend on the amounts of impurity present, but in the present case, which may be taken as a typical one, we found that 0·02 gramme of alum to a liter of water (1·2 grains to a gallon) caused the separation and settling of the impurities, so that the supernatant water could be poured off. This amount of alum was shown by numerous experiments to be about the practical limit. The complete settling took place as a rule in not less, and usually more, than two days. It is evident that the amount of alum thus added is too slight to be perceptible to the taste, and can exert no physiological action. We were unable to detect the slightest taste or change in the water so treated.

Still smaller amounts of alum will produce a precipitate after longer standing. Sixty liters of the city water were treated with two grammes of alum (this was about 31 grains to 16 gallons) and allowed to stand. After forty-eight hours the precipitation seemed complete, and the water was perfectly clear, while the bottom of the vessel was covered with a brownish, slimy deposit. This substance was collected, dried, and analyzed. It gave—

Carbon	16·50 per cent.
Hydrogen	2·02 "
Nitrogen	0·77 "

It is evident from this analysis that a large amount of the organic matter has been removed from the water by the alum treatment.

On incineration, it yielded 59·28 per cent. of ash, which contained silica and alumina in relatively small amounts, oxide of iron in large amounts, and a considerable quantity of phosphoric acid.

To determine if there was free alum in the water, a sample of the clear water, filtered off from the precipitate produced by the alum, was made slightly alkaline with ammonia and warmed for some time. Only the merest traces of an alumina reaction could be obtained, and, in fact, in some cases, it was doubtful if a reaction was observable. To prove that no more matter could be precipitated by the addition of a greater amount of alum, samples of the clean filtered water were treated with more alum, but there was in no case any indication of further precipitation on standing.

We consider it, then, established that, by the addition of two grains of alum to the gallon, or half an ounce to one hundred gallons, water can be clarified by standing, and that neither taste nor physiological properties will be imparted to it by this treatment. By increasing the amount of alum, the time required for the separation and settling can be diminished, and *vic versa*, by diminishing the amount of alum added, a greater time will be required for the clarification.

This method is particularly adapted to the clarification of large volumes of water, where filtration is not practical. The cleared water can be racked off to as low a level as possible, after which the sediment should be washed out and the receptacle cleansed by a free use of water.

II. THE EFFECT OF ALUM IN CLARIFYING WATER BY FILTRATION.

In order to test the clarification of water by filtration after addition of alum, the New Brunswick city water was again made the subject of our experiments. It was found that the suspended clayey matters were so fine that the best varieties of filtering papers were unable to remove them. Even when several layers of heavy Schleicher and Schull paper were used, a very large portion of the suspended matters passed through. This, however, is not surprising, since it is well known that the mineral matters suspended in water are of a remarkable degree of fineness. Thus the water of the river Rhine, near Bonn, cannot be clarified by simple filtration, and takes four months to settle. The addition of certain chemicals aids the filtration of suspended matters in some cases, but it does not always entirely remove them. Calcium chloride and other salts are recommended as effective agents in aiding the removal of suspended matters, but in the case of New Brunswick water, at least, they have no apparent action. The following substances were found to have no effect in aiding the filtration of the water: sodium salts—chloride, carbonate, nitrate, acid carbonate, hydrogen phosphate, acid sulphite, ammonium phosphate, sulphate, biborate, tungstate, acetate; potassium salts—hydroxide, chloride, bromide, iodide, acetate, phos-

* From the advance sheets of the Annual Report of the State Geologist of New Jersey for 1884.

† Putrefaction alkaloid.

phate; ammonium salts—chloride, sulphate, nitrate, acetate; calcium salts—oxide, chloride, sulphate, nitrate. Zinc sulphate and ferrous sulphate (copperas) had no action. Acid sulphate of potassium and of sodium had a slight clearing action. Acetate and chloride of zinc had an apparent action. Ferric chloride (perchloride of iron) cleared perfectly, as also did the nitrate and sulphate of aluminum.

By the addition of a small amount of alum to water, it can be filtered through ordinary paper without difficulty, and yields a brilliantly clear filtrate, in which there is no trace of suspended matter. In our experiments, a solution of alum was added to the water, the whole well mixed by stirring or shaking, and then filtered after standing from one to fifteen minutes. So far as we are able to determine, the coagulative and precipitative action of the alum is immediate upon thorough mixture, and hence it is not necessary to allow the mixture to stand before filtration, but it can be filtered immediately after mixing.

To determine the amount of alum necessary to precipitate this water, alum was added in decreasing amounts to samples of water, which were then filtered through Schleicher and Schull paper. In this way we found that the minimum limit was about 0·02 gramme of alum to one liter (1·16 grains to one gallon). Beyond that point the action of the alum began to be doubtful, and the water, although clarified by filtration, was not wholly clear. To be sure of complete clarification, we took double this amount—0·04 gramme to one liter (2·3 grains to one gallon)—as a standard calculated to give certain results. This amount can be doubled or trebled without fear of any harmful results, but there is no use of adding any more alum than is sufficient to do the work. The determination of the amount of solids removed from the water by the clarification with alum had not yet been finished.

We consider it, then, as established that, by the addition of two grains of alum to the gallon of water, or half an ounce to the hundred gallons, water can be rendered capable of immediate clarification by filtration. The clear water obtained by filtration, after adding this amount of alum, contains no appreciable amount of free alum, and, in fact, in the majority of cases, ordinary tests fail to reveal its presence.

While the clarification of water by standing is very successful, and well adapted to the treatment of large volumes of water, especially when time is not an element of importance, the case will very frequently occur that a relatively small amount of water is to be purified in a short time. In such a case not clarification alone is demanded, but it is necessary that the operation should take as short a time as possible. Again, in order to make this method of clarification practical for domestic use, the operation of filtration must be made extremely simple. No complicated or expensive apparatus should be used, but the filter must be made out of the simplest articles, such as can be found in every household. In this field there is an opportunity for the exercise of considerable mechanical ingenuity, and when the principles of the filtration are understood and more is known about the different kinds of filtering materials, there will doubtless be many forms of house filters devised out of the odds and ends which may be at hand.

It is not a difficult matter to get up a large filter that shall clarify many hundred gallons of water a day in an effective manner. Such apparatus already exists, and is used in manufacturing establishments. In their construction, many points, such, for instance, as the cleansing of the filtering material, have been brought to a high grade of perfection. The difficulty lies in devising some form of simple and cheap filter which will filter a small amount of water as effectively as a relatively large amount, which will be always ready, will always work, will be so simple that any one can understand its operation, can be easily made, not easily broken, but easily repaired if broken, and which will not entail much extra work in order to get a clarified water. The filtering material must be cheap, easily obtainable, easily prepared, capable of being cleansed when clogged by use, or so cheap that it can be thrown away and replaced by new without appreciable expense.

It is evident that the shape, size, and arrangement of the filtering apparatus will depend very largely on the kind of filtering material used. Hence we began by experimenting on filtering media. The glass funnel and carefully folded paper will be of but little service outside of the laboratory. But in cases of great importance, such as the preparation of water for the sick, this method is worthy of attention.

In the large Hyatt filters a mixture of coarsely ground coke and sand is used, and does most admirable and effective work. Granulated bone charcoal also makes a most excellent filtering bed. The most practical material for domestic use, however, so far as we have been able to ascertain, is cotton. Cotton batting can be bought in the shops for about ten cents a pound, and a pound of it will go a long way in filtering. It makes a coherent filtering layer, and when clogged by use can be cleansed by boiling up in the water and rinsing, or, as it is so cheap, can perhaps as well be throw away and replaced by new.

The simplest form of filter for filtering considerable amounts of water is a tube, one end of which is stuffed with cotton. A drain pipe is the best material, since it can be so easily cleansed. The plug of cotton should be from two to three inches thick, and may be held in place by a round piece of wood fitting into the bottom of the drain pipe at its shoulder, and secured by any suitable means. The piece of wood should be perforated, to allow the water to pass through. The shoulder of the pipe may be set in a circular channel cut in a piece of board, and by means of a central channel the water may be made to run off at a point of delivery. In our next report we shall present plans of simple filters, and the results of our experiments with them.

The most practical form of filter for household use, and one that will easily filter a pitcherful of water in a short space of time, can be made out of a bottle. The best form is the long kind in which sweet oil is sold, although almost any kind of glass or earthenware bottle will answer. The bottom of the bottle is cracked off, and the sharp edge removed by rasping with a file. The cracking can be done by tying a thin, soft string, soaked in turpentine, around the place where it is intended to crack, leaving as small a knot as possible, then setting fire to the turpentine, holding the bottle bottom up. After allowing the oil to burn for an instant, the end of the bottle is placed quickly in cold water, when, if the operation has been rightly conducted, an even crack will be produced, and the bottom of the bottle will come off easily.

A layer of cotton is now placed in the bottle. The cotton must be worked in water, preferably warm water, in order to remove the adhering air, and to wet it well. A wad of the wet cotton is propped into the bottle, and covers the mouth of the neck. Other pieces are dropped in, care being taken to build the layer up evenly, and to add the cotton in rather small pieces. After dropping them in, they should be pressed down and arranged by means of a rod. In this way a layer is made which should be from two to three inches thick. It should not be pressed down too tightly, else it may filter too slowly; neither should it be too light, or water may form channels through it. After a little use the plug generally adapts itself. Particular care should be taken to be sure that the cotton is snug against both sides, since the water is liable to escape there. The plugs, however, are easy to make, and a few attempts will soon teach one all the necessary manipulations.

This bottle filter can be suspended or supported in any convenient way. Perhaps the simplest support is a block of wood having an auger hole bored through the center, and the edges of the hole reamed out. In this hole the bottle sits securely, and the bevel of the hole catches the shoulder of the bottle, thus holding it upright. To use this filter, it is only necessary to pour the water, which has been previously mixed with the right amount of alum, into it, when the clear water will run in a considerable stream from the bottom, and can be caught in any convenient receptacle. It is well to throw away the first tumblerful that runs through, if the plug is a new one, as a little sediment will pass through at first, but this soon stops. It is also advisable to keep the bottle nearly full while filtering, as this hastens filtration.

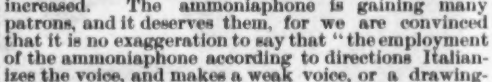
The mixing of the water with the alum previous to the filtration should be done in a separate receptacle. The only requisite here is that the vessel in which the mixing is done must be clean. A pail, jug, can, or any other vessel used in the kitchen will do. It is well to have the pail or can marked on the inside with scratches so as to be able without difficulty to judge how much water there is in it, since the amount of alum should be added in about the right proportions. The eye gets very accurate in judging the volume after a little practice, but it is better and just as easy to be accurate. A clean tin can of two to four gallons capacity is a good size, and, if possible, should not be used for any other purpose than for the drinking water. It should be kept scrupulously clean, and after each use should be washed out and dried. It can be graduated by pouring into it a gallon of water, and marking with a file or other sharp point a scratch just at the level of the water. Then another gallon is poured in, and its level also marked. In this way a graduation is easily made which is sufficiently accurate for all the purposes here intended. As a rule, a can of four gallons capacity will be found quite large enough to filter the water used by a family of average size. The necessary amount of the alum solution is added to the water, the whole well mixed by stirring, and then poured into the filter. Here, again, one or two points should be observed. The mixing is best done with a long handled spoon. A very practical stirrer is a small cake turner, for by means of its flat end a most thorough mixing can be effected. This mixer should not be used for any other purpose than to mix the water. Experience shows that, if the vessels used for mixing or holding the water are not kept perfectly clean, the water may acquire a taste, and this will be laid to the process instead of to lack of care. To facilitate the pouring into the filter, it is well to have the can provided with a mouth or spout. In fact, there is no form of can better than the regular garden watering pot, with its long spout.

The solution of alum is made as follows: Dissolve half an ounce of alum in a cup of boiling water, and when it is all dissolved, pour into a quart measure and fill to a quart with cold water. (This solution should be kept in a bottle labeled "ALUM.") Fifty-four drops of this solution contain 2·3 grains of alum, which is the amount to be added to one gallon of water. The old-fashioned teaspoon holds about forty drops; the new spoons, however, hold about seventy drops. Hence, a modern teaspoon, scant full, will be about the right amount to add to every gallon of water to be filtered. No harm would be done if by mistake two teaspoonfuls are added; in fact, ten teaspoonfuls would have to be added to bring the amount of alum up to the figure recommended by Jeunet (*loc. cit.*). A more satisfactory method will be to procure a small measuring glass. One fluid drachm will be the right amount. It will be found, without doubt, that the amount required for some waters will be even less than that suggested above. We would suggest, therefore, that those who use this method of clarification determine for themselves by experiment how little of the solution is required to make the water they use run through the filter perfectly bright and clear.—*Chemical Laboratory of Rutgers College.*

THE AMMONIAPHONE.

The accompanying diagrams illustrate one of the most remarkable inventions of the age. It is the outcome of twenty-nine years of hard labor in pursuit of a definite object. Dr. Carter Moffat says that when but a boy he was struck with the rather curious idea that the beauty of Italian vocal tone was due to something in the air of Italy, and that Italy as a resort for invalids was due to the same cause. He began at that early age to make chemical experiments, to prepare endless varieties of gases, solid substances, and fluid bodies, to inhale and to partake of these materials, in the hope that his voice might become benefited, and made strong and musical. It was his passion to improve the singing and the speaking voice, and he still felt that the beauty and mellowness of the Italian tone were to be attributed to its atmospheric peculiarities. For more than six years he attended the post mortem rooms of the Glasgow Royal Infirmary, and made over thirty-five analyses of the miliary tubercles in the lungs of persons who had died from consumption.

A little over ten years ago, Dr. Carter Moffat had occasion to visit Southern Italy, and he relates that no sooner had he reached the shores of the Adriatic than he perceived the peculiar tint of the vegetation to be quite different from what it is in our own country. His chemical knowledge at once informed him that the yellow-green tint of the grass, the vine, the olive, the cabbage even, was due to a bleaching action—to something in the air—whence he proceeded to analyze the air and dew of the neighborhood. He says: "Reverentially did I kneel and withdraw that sparkling globule into a glass tube, and with anxious mind I applied a few delicate chemical tests. Roaming from plain to plain and valley to valley, I made over seventy-three analyses of the air and dew. I went to the valley in which the celebrated sympathetic tenor Guiglini was said to have been brought up, and in that peaceful spot I found the atmosphere almost saturated with peroxide of hydrogen and free ammonia. I noted the maximum proportion of hydrogen peroxide to be present in the air about from eleven to two in the daytime, dwindling down to a mere trace at dusk, and developing with the sunlight. The free ammonia appeared to be present in always about the same amount, no matter what hour of the day." These and subsequent experiments proving successful, he devoted himself to the perfection of the ammoniaphone, a task which engrossed his attention for nine years. The instrument which forms the subject of the later patent (taken out by Mr. C. B. Harness) consists of a metallic tube, containing a piece of rope saturated with ammonia, peroxide of hydrogen, and a few flavoring compounds, and provided with a mouthpiece midway between its ends. A ferrule or ring, having an internal screw-thread, is soldered or otherwise fixed at each end of the tube, A. D D are handles, each provided with an externally screw-threaded piece, E, which fits into one of the rings or ferrules, C, so that the handles may be screwed or unscrewed at will. Through each of the handles is passed a rod, F[1], one end of which extends through the piece, E, and carries a plate or disk, F, provided on its inner face with a washer of leather, India rubber, or other suitable material, so as to form a valve capable of closing the orifice or passage in the piece, E. A spiral spring, H, is placed upon each of the rods, F, so that it bears at one end upon the end of a recess or cavity in the handle, and at the other end upon a cap or push-piece, F[2], fixed on the outer end of the rod. This spring tends to press the washer, G, against the end of the piece, E, and thus close the orifice or passage, thereby preventing the admission of air to the tube. A small aperture, I, is formed in each of the handles, D, for the admission of air to the tube, A, when the valve is opened. The mouthpiece, B, has a perforated screw-cap. The person desiring to use the apparatus grasps the handles, D, and applies his mouth to the mouthpiece, B, then, by pressing push pieces, F[2], he



opens the orifices for the admission of air to the tube, A; he can then conveniently inhale the vapor of the substance contained in the tube. The instruments are made of various strengths, the strongest lasting for twelve months, when the saturated rope requires to be renewed. Weaker forms are more generally employed, which, when called into use four times a day, last for about two and a half months. We cannot but bear testimony to the remarkable qualities possessed by the instrument. Prior to determining to notice it, we examined it. One draught of air was inhaled, when, to our astonishment, the intensity of the voice was almost doubled, while its clearness was almost as greatly increased. The ammoniaphone is gaining many patrons, and it deserves them, for we are convinced that it is no exaggeration to say that "the employment of the ammoniaphone according to directions Italianizes the voice, and makes a weak voice, or a drawing-room voice, strong, rich, clear, and ringing."—*Knowledge.*

LIQUID PARAFFIN.

By Leon Crismer.*

Liquid paraffin is an oily substance, consisting of a mixture of hydrocarbons of the marsh-gas series, which boils between 125°–240° under a pressure of 6 mm. It mixes with chloroform and ether in all proportions, forming a clear liquid, provided the chloroform and ether have previously been treated with metallic sodium to remove all water. The addition of a very small quantity of water or aqueous alcohol is sufficient to produce a turbidity in these solutions. This fact may be employed by a means of detecting water in chloroform or ether. In the same way, absolute alcohol dissolves a certain amount of liquid paraffin, forming a perfectly clear solution. A trace of water is, however, sufficient to produce a distinct turbidity.

The author also used liquid paraffin for the preparation of hydrobromic and hydriodic acids. A weighed quantity of phosphorus in the form of sticks is introduced into a flask, and covered with liquid paraffin. A quantity of bromine necessary for the formation of phosphorus tribromide is then gradually added; the flask being kept cool by immersing it in water. A regular evolution of hydrobromic acid may then be obtained by allowing water to enter the flask drop by drop. Hydriodic acid is prepared in a similar way.

HYDROGEN DIOXIDE.

By M. Traube.†

Schonbein's reaction for the detection of hydrogen dioxide, by means of potassium iodide, starch, and iron sulphate, requires a neutral solution. In the presence of free acid the reaction is very much less sensitive; and in very strong acid solution it is impossible to detect minute quantities of the dioxide. The author has found that the reaction loses none of its sensitiveness in strongly acid solutions, if a small quantity of copper sulphate is present. If to 6–8 c. c. of a solution containing potassium iodide, starch, and minute traces of hydrogen dioxide, from 1 to 4 drops of a 2 per cent. solution of copper sulphate and a little of a half per cent. solution of ferrous sulphate are added, a blue color will be produced in a very few seconds.

* Berichte d. deutsch. chem. Gesell., 17, 649.

† Ibid. 17, 1062.

HOW ENGLISH FACTORY OPERATIVES LIVE.

Referring to the general statements in the recent review of factory life and habits in the several manufacturing centers, and to the tabulated rates of wages paid in representative factory centers, the following series of interviews (thirteen in number) with factory operatives, from the report of Consul Lathrop, of Bristol, will give a fair idea of the condition of English factory and mill life.

1. Age, 42 years; occupation, wool scourer; wages, \$4.34 per week; hours of labor, 56; can save nothing; has fresh meat twice a week; wife and eight children; two children, age seventeen and eighteen, receive at self-acting mules \$1.58 each per week. Weekly expenses: rent, 85 cents; fuel, 73 cents; food, \$4.37; clothing, 60 cents; club dues, incidentals, schooling, insurance for six children, \$1.09; total weekly expenses, \$7.64.

2. A spinner, 65 years old; wages, \$4 86 per week; hours of labor, 56; can save nothing; has fresh meat four times a week; wife and seven children; children all married. Week's expenses: rent, 60 cents; fuel, 48 cents; food, \$3.40; clothing, 24 cents; club dues, 30 cents; incidentals, 6 cents; total weekly expenses, \$5.08.

3. A broad loom weaver, 35 years old; wages, \$4.86 per week; hours of labor, 62; can save nothing; has fresh meat twice a week; wife and three children; wife receives at weaving \$1.95 per week. Week's expenses: rent, 79 cents; fuel, 72 cents; food, \$4.13; school, 6 cents; clothing, 24 cents; club dues, 24 cents; incidentals, 60 cents; insurance, 6 cents per week; total weekly expenses, \$6.84.

4. A laborer in woolen wash mill, 57 years old; wages, \$2.68 per week; hours of labor, 58; saves 12 cents a week for Christmas; has fresh meat only on Sundays; wife and nine children, four at home; two boys and one girl receive, as picker, carder, and piecer respectively, \$1.70, \$2.43, \$1.22 per week. Weekly expenses: rent, 60 cents; fuel, 36 cents; food, \$5.60; clothing, 36 cents; club dues, twenty years in shop club, which broke up last year; insurance for three persons, 6 cents; incidentals, 24 cents; schooling, 8 cents; total weekly expenses, \$7 30.

5 A tucker, 25 years old; wages, \$3.90; hours of labor, 56; can save nothing; has fresh meat four times a week; wife and three children; wife receives as weaver \$1.25 per week. Weekly expenses: rent, 73 cents; fuel, 48 cents; food, \$2.80; clothing, 60 cents; club dues, 13 cents; incidentals, 24 cents; insurance for three children, 6 cents; total weekly expenses, \$5.10.

6. Condenser attendant, 40 years old; wages, \$3 40 per week; hours of labor, 60; can save nothing; wife receives \$1.46; meals consist of, for breakfast and tea, bread and butter, perhaps an egg; for dinner, vegetables and a little meat of the cheaper kind. Weekly expenses: rent, 60 cents; clothing, 36 cents; a new suit only once in six years; food, \$3.16; fuel, 36 cents; school fees, 18 cents; club dues, 6 cents; incidentals, 12 cents; total weekly expenses, \$4.86.

7. Warper, 24 years old; wages, \$4.86 per week; hours of labor, 62; has fresh meat three times a week; wife and two children; wife receives as weaver \$2 18 per week. Weekly expenses: rent, 82 cents; fuel, 43 cents; food, \$3.65; clothing, 48 cents; club dues, 40 cents; incidentals, 37 cents; insurance, 4 cents; servant, 85 cents; has to hire servant to take charge of children while at work; total weekly expenses, \$7.

8. Carder, 42 years old; wages, \$3.90 per week; hours of labor, 55; can save nothing; has fresh meat three times a week; wife and five children; wife receives as weaver, \$1.46 per week; two children work, ages 19 and 17, weaver and grocer; weaver, \$1.46 per week; grocer, food and \$1.21 per week. Weekly expenses: rent, 80 cents; fuel, 60 cents; food, \$4.38; clothing, \$1.34; club dues, 24 cents; incidentals 60 cents; schooling, 6 cents; insurance, 14 cents per week for seven people; total weekly expenses, \$8.16.

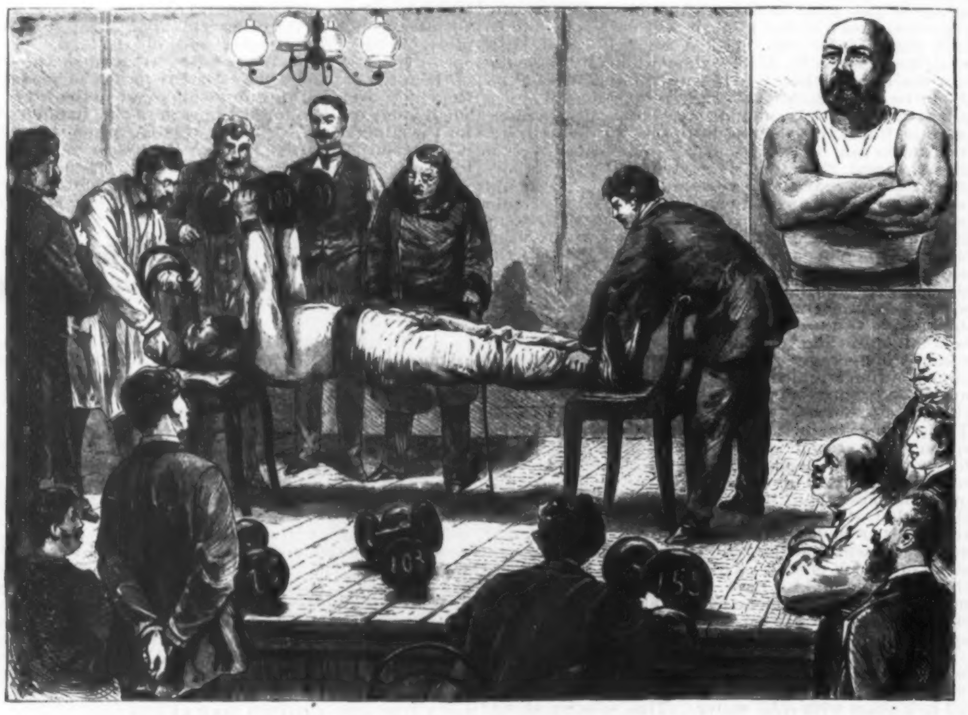
9. Weaver, 37 years old; wages, \$4.86; hours of labor, 62; saves about \$2.43 per quarter; has fresh meat three times a week; wife and five children. Weekly expenses: rent, 60 cents; fuel, 37 cents; food, \$4.38; clothing, 60 cents; club dues, 37 cents; incidentals, 97 cents; schooling, 20 cents; total weekly expenses, \$7.49.

10. Pressman, 25 years old; wages, \$4.38 per week; hours of labor, 57; can save nothing; has fresh meat twice a week; wife and two children; wife receives \$1.50 per week as weaver. Weekly expenses: rent, 73 cents; fuel, 30 cents; food, \$3.65; clothing, 48 cents; club dues, 14 cents; incidentals, 48 cents; insurance, 2 cents per week for one child; total weekly expenses, \$5.80.

11. Fuller, 32 years old; wages, \$4,86 per week; hours of labor, 60; can save nothing; has fresh meat twice a week; wife and five children. Weekly expenses: rent, 61 cents; fuel, 36 cents; food, \$2.92; clothing, 24 cents; club dues, 30 cents; incidentals, 24 cents; schooling, 18 cents; total weekly expenses, \$4.85.

12. Dyer, 35 years old; wages, \$4 88 per week; hours of labor, 55; can save nothing; has fresh meat twice a week; wife and four children; wife receives at weaving 98 cents per week. Weekly expenses: rent, 73 cents; fuel, 37 cents; food, \$3.90; clothing, very little; club dues, 14 cents; incidentals, 24 cents; insurance for two children, 44 cents; schooling, 20 cents; total weekly expenses, \$5.62.

13. Broad loom weaver, 26 years old; wages, \$4.13 per week; hours of labor, 62; can save nothing; fresh meat three times a week; wife and child. Weekly expenses: rent, 43 cents; fuel, 24 cents; food, \$2.92; club dues, 24 cents; incidentals, 37 cents; insurance, 4 cents; total weekly expenses, \$4.24.



ERNST BOHLIG, THE GIANT GYMNAST.

THE GYMNAST, ERNST BOHLIG.

The annexed cut, taken from the *Illustrirte Zeitung*, represents the famous gymnast, Ernst Bohlig, performing one of his most wonderful feats, and also shows his portrait. Mr. Bohlig was born in 1846, in the Palatinate, Germany, but is now an American citizen. He was formerly an apothecary, but several years ago decided to devote all his time to gymnastics. Artists, military officers, medical students, and gymnasts declare Mr. Bohlig to be phenomenal, especially in his exercises with dumb-bells weighing respectively 75, 105, and 155 pounds. He is by no means an ordinary circus performer, as all his motions are graceful and correct. His heart and lungs do not act much more rapidly than under normal conditions, and this is strong evidence of his enormous strength.

As is shown in the annexed cut, the development of the muscles of his arms is enormous, and they are as hard as steel. One of the most difficult feats performed by Mr. Bohlig is represented in the cut. His head and feet rest upon chairs, and that is his only support. In this position he raises two one hundred pound dumb-bells from his breast to the length of his arms six times. A statue of the Farnese Hercules was placed beside Mr. Bohlig in the Imperial Academy of Arts, in Vienna, and by actual measurement it was found that Mr. Bohlig's arms showed a much greater development than those of the statue.

COMPOUND EYES AND MULTIPLE IMAGES.*

My microscopical recreations the past summer were directed mainly upon the structure of the compound eyes of insects, not so much for a definite scientific purpose as with the practical object of discovering what insects have eyes that are the most serviceable for showing multiple images under the microscope. The results thus far obtained are far from exhaustive; yet I have fallen upon some curious features in the structure of these organs, which may possess the interest of novelty to an audience not composed exclusively of entomologists.

These compound eyes, consisting externally of a great number of lenses, sometimes exceeding twenty thousand, set in a framework of convex or, often, hemispherical form, have a range of vision, or "angular aperture," very much larger than could be commanded by a simple eye of the same convexity. For, while the simple eye could form correct images of those objects only which are situated within the range of rays passing through its optical axis, the minute lenses composing the compound eye may, many of them, receive light from a horizon as low down as the base of the entire set, if not lower.

In some species of Neuroptera the head is nearly cylindrical, and is placed with its axis transverse to the axis of the insect's body. As the eyes, constituting, of course, the extremities of the cylinder, have a diameter exceeding that of their support, and are, besides, hyperhemispherical, they give to the head the appearance of a dumb-bell. Were one of these insects placed at the center of a hollow sphere, it could, undoubtedly, see at the same moment every point of the sphere's interior surface.

The *Gyrinus*, or water-beetle, which may be seen sporting on the surface of still water in summer, has the unusual number of four compound eyes. Besides the usual pair on the upper and frontal part of the head, set in the under side of head is another pair, looking directly downward and completely submerged—"water immersion" eyes. The utility of this arrangement is readily seen. Its anatomy I have not myself examined; but I have somewhere heard or read that the two eyes on each side, though separated externally, are in a measure connected internally. The *Gyrinus* is the only example of this peculiar structure that has come under my observation.

To those who admire color, a microscopical observation of the eyes of living insects, especially those of the order Diptera, and of the night-flying Lepidoptera, will be fruitful of delight. For the eyes of these insects display an endless variety of colors which vie in brilliancy with the most lustrous of the "bright jewels of the mine." After the death of the insect, however, the color soon disappears.

In mounting compound eyes for the purpose of showing multiple images, the first step, after carefully washing the interior of the cornea, is to press the cornea flat, so that all the lenses may lie as nearly as possible in the same plane. But as this operation necessarily occasions either a breaking or folding of the cornea, I cut out, with a small punch made for the purpose, a circular disk not larger than can be pressed flat without disturbing the facets. In punching out these disks, a single cutting gives two circular pieces, showing that the cornea is double; and in the eyes of *Cicada*, a single cutting gives three separate disks showing a triple set of lenses in the cornea. Each set constitutes, without doubt, an achromatic combination.

In some of the Diptera, particularly of the genus *Tabanus*, or horse-fly, the lenses of the upper and anterior part of the eye are much larger than those situated below a median line. A disk cut from one of these eyes in such a way as to include a number of the upper or larger facets, and also some of the lower, shows that the larger facets have at least twice the diameter of the smaller, or four times their superficial area. A still more remarkable feature, however, is the difference in focus between the larger lenses and the smaller. For upon placing this part of the eye upon the stages of the microscope, and adjusting the focus for multiple images, I found that the larger lenses form pictures at a plane considerably above the focal plane of the smaller ones. From this fact it would appear that these insects are furnished with eyes of two varieties, corresponding to our long sight and short sight spectacles; in other words, telescopic and microscopical eyes, the telescopic looking upward and forward and the microscopical downward. The economy of such an optical structure in a parasitic insect which seeks its prey at a distance is so obvious that I need not stop to explain it.

For showing multiple images, the most perfect eyes that I have yet found are those of *Blatta orientalis*, or the cockroach. As the eyes of this insect are quite brittle, only a small part of the cornea can be pressed flat in one piece. Yet a piece large enough to fill the field commanded by a ½ in. objective and a B ocular can be cut out with the punch. The many advantages which it possesses more than counterbalance its lack of superficial extent. For the lenses are very transparent, and comparatively large, and, being set in a moderately hard framework, do not separate so as to destroy the achromatic combination. Nor do the lenses which make up each combination slip upon one another when subjected to slight pressure, as do the lenses in the eyes of most other insects except the Coleoptera. When the lenses do thus slip upon one another, each separate eye shows two or three imperfect images instead of a single good one. The chief advantage, however, which the eyes of the cockroach possess over all others is that they may be mounted in glycerine, and thus kept perfectly transparent without losing their properties as lenses.

The usual method of exhibiting the mutiple images is to place the mounted cornea of the compound eye upon the stage, and focus the microscope so much above it as to show a clear circle of light in each facet. Then, if any small object be placed between the stage and the mirror, its image will be exhibited by every lens. Also if a small letter, figure, or picture, in black, with a clear, white background, be placed 1 in. or 2 in. below the stage, and a strong light be condensed upon it, it will be seen with tolerable distinctness. Such objects are, however, much more sharply defined if first cut out, and then pasted upon a thin cover glass, which may be mounted on the sub-stage. In this situation the object is illumined by light reflected from the mirror. The effect will be still better if a slip of ground glass be interposed between the object and the mirror, so as to shut off the image of the lamp, if lamplight be employed, or of distant objects, if daylight be used. The eye of a mosquito will show two or three hundred pictures of a person, in silhouette, with great distinctness, provided you have a window so situated as to allow light from the sky or from a white cloud to pass unobstructed to the mirror. The person must stand at a distance of 5 ft. or 6 ft. from the microscope, and with the profile of his face in clear relief against the sky. The plane mirror must, of course, be used.

I have recently been much interested in examining the structure of the eye of *Limulus*, or the horse-shoe crab, which, though compound, is quite different, in some particulars, from that of insects. The exterior of this eye is perfectly smooth, and consists of a transparent horny coat of considerable thickness. The concave interior surface is studded with lenses varying in form from plano-convex, near the center, to conical and paraboloid, toward and at the periphery. These lenses are so placed that their optical axes converge to a common point situated in a plane a little below the base of the whole eye. This point, without doubt, is

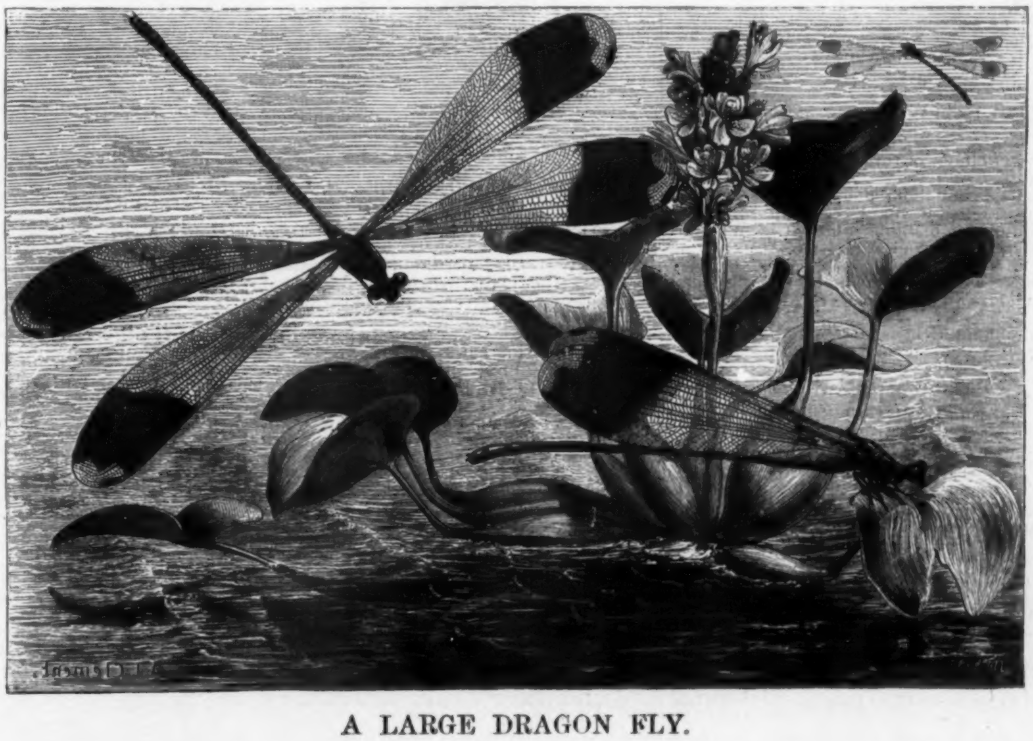
* By J. D. Hyatt, from the *Journal* of the New York Microscopical Society.

occupied by the retina, or the extremity of the optic nerve. Good multiple images will be made by this eye if a small disk cut from the central part be used, the eye being flattest at that point and the lenses least conical. From any other part of the eye it would be extremely difficult to cut a disk that would not, in consequence of the oblique position of the lenses, greatly distort the images.

Multiple images may be formed under the microscope in many other ways than by the use of compound eyes. The minute plano-convex bodies of water produced by breathing on a slide will display good images of any small object supported above the mirror. In like manner, images will be made by other transparent bodies, or by the transparent parts of any structure, which are of lenticular or globular form. Concave lenses, as well as convex, will give images, but with this difference—the images will be found below the plane of the foci of the lenses, and will be inverted; whereas, images produced by convex lenses are formed erect and, as before stated, at a plane above such focus. It follows that air-bubbles in water will yield inverted images, the water immediately surrounding them acting as a biconcave lens. These facts may possibly be of some service in determining the character of minute bodies or structures, such, for example, as human blood corpuscles, all of which show erect images—a proof that they are nucleated or at least lenticular at the center. The herd of the pin-shaped sponge-spicule, and the nuclei in certain diatoms, produce inverted images.

A LARGE DRAGON-FLY.

IN France we give the vulgar name of *demoiselles* to certain neuroptera that have wings reticulated like gauze, and a slender elongated body, which, during life, is often decorated with most delicate and brilliant colors, that, unfortunately for collectors, tarnish or disappear through drying. The name given by the English to these insects—that of "dragon-fly"—is much more appropriate, since they are robust carnivora, and are continually lying in wait for butterflies and flies, which they seize on the wing and tear into pieces with their strong scissors-like mandibles.



A LARGE DRAGON FLY.

Their metamorphoses are incomplete, the first stages of their existence being passed in the water, a circumstance that has caused them to be styled amphibious neuroptera. Their larvæ, which are elongated and of a yellowish gray, crawl about in the mud, and, by means of a folded lip terminating in a sort of nippers that they suddenly open, seize and feed upon insects and mollusca which they are ever stealthily lying in ambush for. These larvæ gradually pass to the state of nymphs, acquire wing covers, and still preserve the agility and carnivorous habits of their former stage. These nymphs make their exit from the water, and fasten themselves to some support, such as a reed or rush. The skin then splits along the back, and the large wings, which were at first folded and crumpled, leave their cases, spread out, and became stiff upon drying in the air. Then the adult flies away, leaving the empty nymphal skin sticking to the support.

One group, that of the *Libellulæ*, which we observe flying during fine weather, exists under the form of various species that are renewed from one epoch to another. Each *Libellula* selects a hunting territory from which it expels all rivals and flies in a straight line to roadsides, along hedges, and paths in the woods. These insects often rest upon small branches in order to warm themselves in the sun, and at such moments spread out their large wings horizontally.

Another type is that of the Agrions which as a general thing do not stray so far away from water as the preceding, for their wings (the two pairs of which are equal) are weaker. When at rest, they place the latter perpendicularly along the body, and not at right angles to it. Their body is much elongated and very slender, and is often decked with the most beautiful colors—azure blue, milk-white, and golden bronze. Their eyes are very wide apart and prominent, and are borne upon pedicels, making them panoramic organs of sight for seeking out the puniest insects. Upon looking at one of these insects from above, we obtain the aspect of a triangle with rounded angles, due to a transverse and depressed head, widely spaced eyes, and a projecting mouth.

In the warmest regions of America there are species of this group that retain the form of our European species, but are of much larger size. One magnificent species is that represented in the accompanying engraving. This insect, which is indigenous to Colombia and the Bay of Honduras, is rare, but has been known to collectors for a long time. It forms a particular genus, that of *Megaloprepus* (Rambur), with the specific name *Cærulatus* (Drury). The spread of its wings is 6½ inches and its length nearly five. Its dominant color is dark or blackish violet blue. Its head is yellow beneath, its violet thorax has longitudinal yellow lines, and its breast is yellow. Its abdomen is slender, a little thicker at the extremities, a little inflated at the incisions, and yellow upon the sides and beneath the first two segments, the others having a line of the same color upon the lower part of the sides, all the rest of a dark violet. Its wings are very dark and wide, rounded at the extremity, very shiny and transparent, and have quadrangular black spots at the extremity, and, a little in front, a wide band of violet-brown, which is somewhat sinuous and oblique at its interval edge.

There are Agrions which have still more elongated bodies than the species under consideration. For example, the *Megistogaster linearis*, Fab., of Brazil, has an abdomen 6½ inches in length. In the accompanying engraving we figure a *Megaloprepus* at rest upon a floating aquatic plant of the hot regions of equinoctial America, where insects and flowers rival each other in brilliancy and strangeness of form. This plant is called *Pontederia crassipes*, and belongs to the family Pontederiaceæ. Its leaves are of a bright green, and are remarkable for their petioles being swollen so as to form swimming bladders. The peduncles, which issue from the slit leaf-petioles, are provided near the center with an ordinary leaf beneath the spike of flowers. Each flower exhibits a petaloid calyx that forms a perianth with the corolla. There are six unequal stamens, and one three-celled ovary with thick stigma. The fruit is a capsule enveloped by the persistent base of the perianth. The flowers are blue.—*La Nature.*

THE CULTURE OF MICROBES.

Is it necessary to recall what was the starting point of all the processes that are being employed in our day for the isolation and cultivation of the different species of microbes? We have now no trouble in admitting that liquids—even the most putrescible ones—decompose only in the presence of hosts of minute vegetable organisms, and that contagious diseases are the work of these micro-parasites. For the younger generation of naturalists these ideas have become an axiom. We no longer endeavor to ascertain whether such and such a fermentation or contagious disease is indeed caused by microbes, but to find out what the guilty species is for each.

And yet the now settled question of spontaneous generation has given rise to discussions that are not so old as to be already forgotten. If Mr. Pasteur has not been the sole defender of the theory of organized ferments, he has certainly been its principal and most valiant champion. For many years back he has been keeping up a single-handed fight with the partisans of spontaneous generation, whose repeated attacks have not been useless, since they have obliged him to put his inventive genius under contribution in order to answer every objection by an experiment without reply.

Such is the origin of all those inventions that are the base of our culture processes. The art of depriving the air or putrescible bodies of every living germ was not as easy at the beginning as it is now. It required much experimentation to ascertain that the temperature of ebullition of water does not suffice to kill the spores of many microbes, and that in the dry state they succumb only at a heat of more than 150° kept up for several consecutive hours. Their tenuity is such that they pass with water through all ordinary filters, and are only held back by the stratum of plaster employed by Mr. Pasteur or the earthen filter that Mr. Toussaint has brought into use. The air, being less dense, allows the germs that it holds in suspension to deposit much more easily. It is only necessary to cause it to traverse Mr. Pasteur's bent capillary tube or the wad of cotton proposed by Messrs. Schroeder and Tyndall.

Enriched by these experiments, it is now easy for us to fulfill the first condition of all experimentation in the field of micro-biology, that is to say, to obtain eminently putrescible substances which are nevertheless preserved through contact with filtered air, because we have succeeded in depriving them of all living germs. It goes without saying that they will be preserved in glass vessels. These vessels will have to be closed with a permeable stopper that will allow of the passage of the air or any other gas that it is desired to introduce, or that will permit of a vacuum being formed without removing it. The form of the orifice and the arrangement of the stopper will have to be so combined as to allow the experimenter to have easy access without danger of accidental contamination. It is from the latter standpoint that the systems proposed up to the present time leave most to be desired.

We can obtain a perfectly sterile putrescible liquid, that is to say, one free from living germs, by any one of the four following means:

1. By filtering through a permeable substance whose pores are fine enough to retain the smallest germs. The only material for such a purpose that is really practical is the unglazed porcelain brought into use by Messrs. Pasteur and Chamberland.

2. By drawing the liquid directly from the internal organs of a perfectly healthy animal. We do not speak of the digestive tube, since this must be considered as an external organ. It has been affirmed, in fact, since Mr. Pasteur's experiments, that the organism of the higher animals is one of the most perfect filters known. It allows no foreign germ to pass, and tolerates none, so long as it has not succumbed to disease.

3. By a sufficiently prolonged heating at a temperature of at least 100° C. It requires no less than this to kill the most resistant spores, although vegetating microbes succumb at 80°. The heating should in no case last less than an hour. The more it is prolonged, the completer the security.

4. By the discontinuous heating invented by Tyndall, and much employed in Germany. It consists in first causing the spores that the putrescible substance contains to germinate, in order to make it possible to kill them at 80°. To effect this, the culture vessels are placed in a stove kept at 25° or 30°, so as to favor germination, and the temperature is raised every day to 80° in order to kill the spores that have germinated. With this method it takes a long time to reach the end in view, and the result is always incomplete and uncertain.

Of all these processes, the third undoubtedly presents the most security, and is the one most easily performed. We employ it by preference to every other, and recognize but one defect in it, that of causing the precipitation, in an insoluble state, of all the albuminous substances coagulable at the temperature at which water boils. We shall describe this process, with all the improvements introduced by the author of it, and in its most modern and practical form.

The first thing to be done is to close the vessels that are to receive the sterilized liquids with stoppers permeable to the air. The plan of closing that we have finally adopted will be described further along. Thus stoppered, the vessels are placed in a stove, and the latter is raised to, and kept at, at a temperature of 160° C. for at least three hours. If this degree of heat could be exceeded, the sterilization would be effected more quickly, but the cotton wads would burn. It is therefore necessary to hold to the temperature indicated. With a gas stove it is easy to moderate the flame, and consequently to have an automatic regulation by means of a regulator whose bulb enters the center of the stove. In the absence of gas, such results could only be reached through continuous surveillance. It would be easier to dispense with a thermometer. The cotton takes the place of the latter, since it begins to scorch (without carbonizing, however, when the desired temperature is reached. The stove should have double sides, but its shape is immaterial. To those who have the means we may give as a model the one that Mr. Miquel has had

constructed at the Montsouris Observatory. Mr. Wiesneg has constructed a smaller one, which is provided with a glass door, and works very well, as long as the heat does not crack the glass. At Geneva our financial means have not allowed us to go beyond an old sheet iron furnace with double sides. This, however, works perfectly well. The cooling must be gradual, in order to avoid breaking the glass vessels. The air, expanded by the heat, gradually enters through the wad of cotton, and is thus perfectly filtered. It is well to sterilize in advance an ample supply of vessels of all forms, which should be kept in a closet to protect them from dust.

The second operation consists in preparing the sterilized liquid and introducing it into the vessels. We prefer natural bouillon (prepared according to the recipe of Mr. Miquel) to all artificial mixtures. This recipe may be found in Miquel's work, "Les Organismes vivantes de l'Atmosphere." One pound of lean beef is cooked for five hours in three points of water. The resulting bouillon, after being skimmed at the end of the ebullition, is allowed to remain in a cool place until the next day, when the fat is skimmed off, and it is neutralized with caustic soda. After this it is filtered

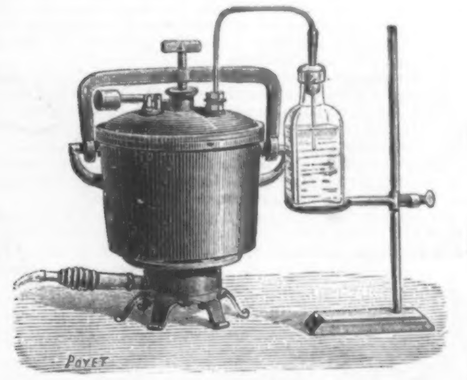


FIG. 1.—DIGESTER.

and brought to the original volume of three pints, and then boiled for ten minutes.

We notably prolong this second boiling (about one hour), and perform the operation in a digester regulated to 110°, after adding 1¼ ounces of table salt to the bouillon. The liquid, after being cooled, and passed through a double paper filter, is put back into the well washed digester, and kept at a temperature of 110° again for at least three hours, in order to sterilize it effectually.

Instead of natural bouillon, an artificial one may be made with the following ingredients:

Chemically pure peptone	75 grains.
Basic phosphate of soda	150 "
Muriate of ammonia	75 "
Liebig's extract of beef	75 "
Cane sugar	300 "
Table salt	75 "
Water	2 pints.

The mixture is carried to ebullition, or, better yet, heated to 110° for half an hour, then filtered, and put back into the digester. It is more easily and quickly made than beef bouillon, but the quality of the product depends upon that of the peptone, a variable and easily alterable substance. If it be desired to obtain a nutritive jelly instead of a bouillon, it is only necessary to add to the latter (natural or artificial) from ¾ to 1½ ounces of pure colorless gelatine that has been dissolved before the last filtration. The filtration in this case will have to be performed in a funnel that dips into a bath heated to 50° or 60° C. as long as the operation lasts. The other manipulations are the same as for the bouillon, save that it is necessary to avoid sterilizing for more than an hour in the digester, under the penalty of seeing the gelatine lose its property of thickening upon cooling. Instead of gelatine, we may employ agar-agar, the jellies of which are capable of supporting a temperature of nearly 30° without liquefying. This substance dissolves but partially in boiling water, but that difficulty we easily surmount with our

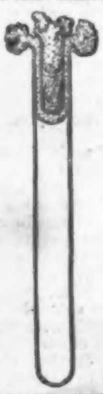


FIG. 2.—PRESERVING TUBE.

FIG. 3.—THE SAME, WITH CANULA.

digester. At 110° the solution is complete at the end of an hour. We filter while hot, and sterilize anew at 100° or 120°. Agar-agar is more resistant than gelatine, and does not suffer from a prolonged heating.

The digester (Fig. 1) in which the sterilizing is performed has three apertures. The first is for the safety-valve; the second is of conical shape, and closed by a cork stopper held in place by a screw; and the cap of the third contains an aperture through which a metallic tube passes with hard friction. This tube is bent twice at right angles, after the manner of a siphon. There is adapted to it, by means of a thick rubber tube, a metallic canula of special form. It is a trocar tube to the extremity of which a trocar point has been soldered. In the side, a little beneath the soldering, there is an oval aperture. The rubber tube is kept closed by means of a spring clip.

When the liquid has been sterilized by quite a prolonged heating, the bent tube is drawn up so that its lower extremity is in the upper part of the digester filled only with steam. If the clip be now removed, the steam, heated to 110°, will traverse the tube and escape through the lateral aperture of the canula in a powerful jet. In ten minutes time the tube and canula will be thoroughly cleaned and sterilized. Then the clip is put on again and the tube is pushed down to the bottom of the digester. Now when the clip is again removed from the tube, the sterilized liquid will be seen to escape from the canula in the form of a jet, thanks to the pressure that exists in the digester.

It is only necessary, then, to pass the canula through the wad that closes a sterilized vessel in order to make the liquid pass from the bottom of the digester into the bottom of the glass without possible contact with the external air. There was, however, one difficulty to surmount relative to the perforation of the stoppers.

FIG. 4.—SUPPORT FOR TUBES.

Wadding in a mass offers an almost insurmountable resistance to the passage of the sharpest point. In a thin layer it allows itself to be perforated more easily, provided it is well stretched. Asbestos and mineral wool are easily pierced. This observation has permitted us to combine a mode of stoppering that is at once perfect and simple, and that allows of the easy passage of the canula. After employing various arrangements, we have adopted one that appears to us to present the great advantages of simplicity and convenience.

Glass vessels are selected whose neck is nearly ¾ inch in internal diameter, and an ample supply of small glass tubes is procured from a glass blower. These should be about a sixth of an inch in diameter by one inch in length, and like test tubes in shape. The bottom should contain an aperture one or two lines in diameter. These little round-bottomed tubes serve to form stoppers that are at once hermetical and easily traversed by a pointed canula. We use them as follows: On the neck of the vessel to be closed we lay a bit of wadding, and then insert one of the tubes. The wadding thus forms a compact layer between the tube and the neck of the vessel. Then we fill the tube half full of asbestos and half full of wadding (Fig. 2). After complete sterilization by dry heat, we remove the last wad of cotton at the very moment of filling, so that the point of the canula has nothing to come into contact with but the asbestos (which it easily traverses) and a thin layer of taut wadding which offers no resistance to the passage of the point, and which prevents the latter from carrying any asbestos along with it (Fig. 3). This system has been adopted only after long experimentation, and because it has shown itself on usage very practical and expeditious. It is equally applicable to all vessels, bottles, tubes, etc., whatever be their shape, provided their neck remains within the limits of the diameter of the ordinary bottles in use.

For cultures, however, we prefer the ordinary test-tubes used by chemists, and flat-bottomed conical vials (Fig. 5). The former we place in wire supports (Fig. 4).

By these methods, then, we are provided with a simple and rapid means of producing an unlimited number of nutritive preservatives in a short time. It remains to see how these are employed in cultures and the numeration of the germs of the air.

The danger to be avoided during these operations is

FIG. 5.—CULTURE VIAL.

accidental contamination by germs held in suspension in the air, and, what is infinitely more dangerous, contamination by the germs that adhere in great number to all objects that have not been carefully submitted to flames. This latter operation consists in heating up to 300°, in a flame, all the instruments that may come into contact with the culture liquids. Well performed, this operation doubtless gives great security, but it is subject to quite serious objections. If the culture sowing be removed with an instrument that is still hot, we run the risk of killing it, and of seeing the sowed liquid remain sterile. If we await a complete cooling, it may happen that new germs from the air have deposited thereon in the interval. With dexterity, we can, to a certain point, avoid this danger, but it is preferable, and in reality simpler, to have recourse from the beginning to a more accurate manipulation.—*Dr. H. Fol, in La Nature.*

NORTHERN CORN THE BEST.

SOME analyses of canned sweet corn, recently made by Professor Geisler, show a remarkable difference between that grown in different sections of the country. Samples from Maryland, Iowa, and Maine were analyzed, and the results show that, if the food value of the corn raised in Maine is taken at 100 per cent, that from Iowa has a value 76·7 per cent, and that from Maryland 66·4 per cent. In dollars and cents, these values would be expressed by a price of $1.20, $1.00, and 80 cents respectively. It will thus be seen, says *Science News*, that the general impression of the superiority of Eastern and Northern sweet corn is a correct one, and borne out by scientific investigations.

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